ERDC/CERL TR-06-8

Construction Engineering Research Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Energy and Process Optimization Assessment

Fort Stewart, GA

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Final Report

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Washington, DC 20314-1000

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Abstract: An Energy and Process Optimization Assessment (EPOA) was conducted at Fort Stewart, GA (FSG) to identify energy, process, and environmental opportunities that could significantly improve the installation's mission readiness and competitive position. The study was targeted at creating a holistic approach to energy optimization in both non-industrial and industrial facilities and included measures related to industrial processes, building envelope, and energy and mechanical systems. A team of researchers and expert consultants performed a Level I and limited Level II EPOA for 2 weeks beginning 18 July 2005. The scope of the EPOA included: the central energy plants at both Fort Stewart and Hunter Army Airfield, several industrial and non-industrial buildings, and an analysis of their building envelopes, ventilation, compressed air systems, lighting, and individual steam boilers. The study identified 42 energy conservation measures (ECMs); 22 of these were quantified economically. Implementing the 22 ECMs will reduce FSG energy and operating costs by approximately $1.89M, will yield an average simple payback of 5.3 years (64 months), and will improve the work environment.

Executive Summary

During the past few years the U.S. Army Corps of Engineers, Construction Engineering Research Laboratory (ERDC/CERL) has been involved in energy and process optimization to assist Department of Defense (DOD) installations in meeting energy efficiency and environmental compliance requirements and to create an improved work environment through "Energy and Process Optimization Assessments" at Army manufacturing and repair facilities. The developed "Energy and Process Optimization Protocol" was tested and successfully applied at numerous energy assessments at Army Material Command (AMC) Arsenals, Depots, and Army Installations. Recently, this effort was extended to development of the protocol and conducting energy assessments at non-industrial facilities through participation and leadership in the IEA ECBCS Programme Annex 46 "Holistic Assessment Toolkit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo)," sponsored by Installations Management Agency and the Office of the Assistant Chief of Staff for Installation Management (OACSIM).

The Energy Assessment Protocol (protocol) is based on the analysis of the information available from the literature, training materials, documented and non-documented practical experiences of contributors, and successful showcase energy assessments conducted by a diverse team of experts at US Army facilities. The protocol addresses both technical and non-technical organizational capabilities required for successful assessment geared toward identification of energy and other operating costs reduction measures without adversely impacting indoor air quality, product quality (in the case of manufacturing or repair facilities), safety, or morale.

A critical element for any audit team member is the capability of applying a **"holistic" approach** to the energy sources and sinks of the audited target (installation, building, system, or their elements) and **"stepping outside the box."**

The process outlined in the protocol allows identification of resource consuming activities, and wasteful practices, prioritization of conservation opportunities, implementation of best practices, and guides investment in resource-conserving technology upgrades. The protocol addresses several

different scopes (building stock, individual building, system and component) and depth levels of assessment:

- *Energy conservation opportunities analysis*. This involves no instrumentation using basic analysis to generate a list of top energy saving ideas (Level 1).
- *Energy optimization analysis geared toward funds appropriation*. This calculates savings and uses partial instrumentation with cursory analysis (Level 2).
- *Detailed engineering analysis with implementation, M&V*. This includes performance measurement and verification assessment, and a fully instrumented diagnostic audit (Level 3).

This energy assessment protocol is geared to assist the following target groups of users:

- Facility energy managers and in-house energy assessment groups,
- Companies providing energy assessments,
- Universities conducting energy assessments, and
- Energy Service Companies (ESCOs).

The energy assessment at Fort Stewart, GA (FSG) is one of the showcase assessments supported by IMA and conducted by CERL with participation of a diverse group of energy assessment experts with objectives to test and demonstrate the energy assessment protocol, and identify energy, process, and environmental opportunities that could significantly improve the installations' mission readiness and improve soldiers' wellbeing.

A CERL lead team performed a Level I assessment and a limited scope Level II assessment during the 2-week period beginning 18 July 2005. The scope of the Level I assessment included: the central energy plants and distribution systems at Fort Stewart and Hunter Army Airfield, several industrial and non-industrial buildings with the analysis of their building envelopes, ventilation, compresses air systems, lighting, and individual steam boilers. The study identified 42 energy conservation measures (ECMs); 22 of these were quantified economically. Implementation of the 22 ECMs will reduce FSG energy and operating costs by approximately $1.89M, and will yield an average simple payback of 5.3 years (64 months), and will improve the working and learning environment.

The Level II assessment was focused on ECM's generated from the Level I assessment and approved by the DPW Staff. The end product of the Level II analysis was four (4) Energy Conservation Investment Program (ECIP) projects for funding consideration and implementation These four projects

included: (1) barracks dehumidification using a dedicated outdoor air system, (2 – 4) various combinations of cogeneration systems at the central energy plant.

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Preface

This study was conducted for Fort Stewart, GA (FSG) under Project Requisition No. 127396, Activity A1020, "Annex 46 Holistic Assessment Toolkit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo)," via Military Interdepartmental Purchase Request (MIPR) 5JCERB1040R. The technical monitors were Fred Louis, Energy Manager, Fort Stewart, and Paul Volkman, Headquarters, Installation Management Agency (HQ-IMA).

The work was managed and executed by the Energy Branch (CF-E) of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). The CERL principal investigators were Dr. Alexander Zhivov and John L. Vavrin. Appreciation is owed to Fred Louis (FSG) for his coordination of the FSG team and to the FSG DPW who contributed significantly to the information gathering and feasibility analysis. Major contributors to the study were Al Woody, and Michael Chimack and Robert A. Miller (Energy Resources Center, University of Illinois at Chicago [UIC]). Dr. Tom Hartranft is Chief, CEERD-CF-E, and Mr. L. Michael Golish is Chief, CEERD-CF. The associated Technical Director was Dr. Paul A. Howdyshell, CEERD-CV-T. The Acting Director of ERDC-CERL is Dr. Ilker R. Adiguzel.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL James R. Rowan, and the Director of ERDC is Dr. James R. Houston.

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
British thermal units (BTU, International Table)	1,055.056	joules
MMBtu	0.293	MWh
cubic feet	0.02831685	cubic meters
cubic inches	1.6387064 E-05	cubic meters
cubic yards	0.7645549	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
gallons (U.S. liquid)	3.785412 E-03	cubic meters
inches	0.0254	meters
miles (U.S. statute)	1,609.347	meters
miles per hour	0.44704	meters per second
square feet	0.09290304	square meters
square inches	6.4516 E-04	square meters
square miles	2.589998 E+06	square meters
square yards	0.8361274	square meters
tons (2,000 pounds, mass)	907.1847	kilograms
tons (2,000 pounds, mass) per square foot	9,764.856	kilograms per square meter
yards	0.9144	meters

1 Introduction

Background

Fort Stewart, GA

Fort Stewart and Hunter Army Airfield (a component of Fort Stewart) are the homes of the 3rd Infantry Division, and combine to be the Army's Premier Power Projection Platform on the Atlantic Coast. Fort Stewart is the largest military installation east of the Mississippi River, covering 280,000 acres including parts of Liberty, Long, Tattnall, Evans and Bryan counties in southeast Georgia. Fort Stewart's cantonment area is located 42 miles southwest of Savannah, and is the largest Federal landholding in the state of Georgia. Fort Stewart has over 2,000 buildings, totaling over 11.4 million sq ft of conditioned space.

Hunter Army Airfield is home to the Army's longest runway on the east coast (11,375 ft) and the Truscott Air Deployment Terminal. Together these assets are capable of deploying units such as the heavy, armored forces of the 3rd Infantry Division or the Army's special operations unit, the 1st Battalion, 75th Ranger Regiment. Hunter Army Airfield is located in Chatham County adjacent to the southwest side of the city of Savannah, and covers 5,370 acres. The airfield runway can accommodate any aircraft in the U.S. air fleet. This capability is critical to Hunter Army Airfield's role as a "power projection platform," or a location from which forces can easily deploy by air or by sea.

Rapid deployability of the division is ensured by Fort Stewart's proximity to the port of Savannah and Hunter Army Airfield. Only 40 miles from Fort Stewart and 5 miles from Hunter Army Airfield, the port is easily accessed by an interstate road network and multiple rail lines leading directly to dockside.

Fort Stewart and Hunter Army Airfield have consistently proven rapid deployment capabilities in operations ranging from the 1990 Gulf War through annual deployments to Europe, Africa and the Middle East, and most recently, to operations in Afghanistan and Iraq.

Energy and Process Optimization Assessment at Fort Stewart, GA

CERL assembled a multi-disciplined project delivery team to conduct an Energy and Process Optimization Assessment of Fort Stewart, GA. The team critically analyzed several functions on the installation, developed recommendations, and presented results to installation leadership. Guided by the Fort Stewart, GA (FSG) Directorate of Public Works (DPW) staff, CERL researchers and subject matter experts (SMEs) analyzed the various facilities for 2 weeks starting on 18 July 2005 to review performance improvement opportunities and develop workspace consolidation strategies. Researchers found that the DPW had identified significant energy reduction goals using its own resources and through Energy Savings Performance Contracts (ESPCs). The brief tour and subsequent discussions made it clear that it would be beneficial to consider an holistic approach to energy optimization in the industrial workspace and non-industrial buildings.

This holistic approach would include measures related to operational processes, building envelope, and energy and mechanical systems. Energy conservation efforts will be combined with measures directed toward improved ventilation systems performance, resulting in a healthier and more comfortable working environment. After these improvements, the Fort Stewart site may become a showcase example for other DOD installations.

This study is the first of a series of similar studies to be done at four other Army installations to identify energy and performance improvement opportunities, to develop workspace consolidation strategies, and to work with base engineers and contractors to apply these strategies. Future assessment efforts at other installations will follow and improve on the “lessons-learned” at Fort Stewart.

Objectives

The objectives of this study were: (1) to conduct an installation wide Level 1 energy and process optimization assessment and (2) to conduct a limited scope Level II analysis resulting in the “appropriation grade” performance improvement projects for funding and implementation. Additionally, this showcase assessment was to test and demonstrate the energy assessment protocol that CERL and its international partners are developing as a part of the International Energy Agency (IEA) Energy Conservation in Buildings and Community Systems (ECBCS) Program Annex 46.

Approach

The study was conducted using an Energy Assessment Protocol developed by CERL in collaboration with a team of government, institutional, and private sector parties as a part of the IEA ECBCS Program Annex 46. This protocol is based on the analysis of the information available from the literature, training materials, the documented and non-documented practical experiences of contributors, and previous successful showcase energy assessments conducted by a diverse team of experts at the U.S. Army facilities.

The protocol addresses both technical and non-technical organizational, capabilities required to make a successful assessment that is geared to identifying energy and other operating costs reduction measures without adversely impacting indoor air quality, product quality, or (in the case of manufacturing or repair facilities) safety and morale.

A critical element for energy assessment is a capability to apply a "holistic" approach to the energy sources and sinks in the audited target (installation, building, system, or their elements). The holistic approach suggested by the protocol includes the analysis of opportunities related to the energy generation process and distribution systems, building envelop, lighting, internal loads, HVAC, and other mechanical and energy systems (Figures 1 and 2).

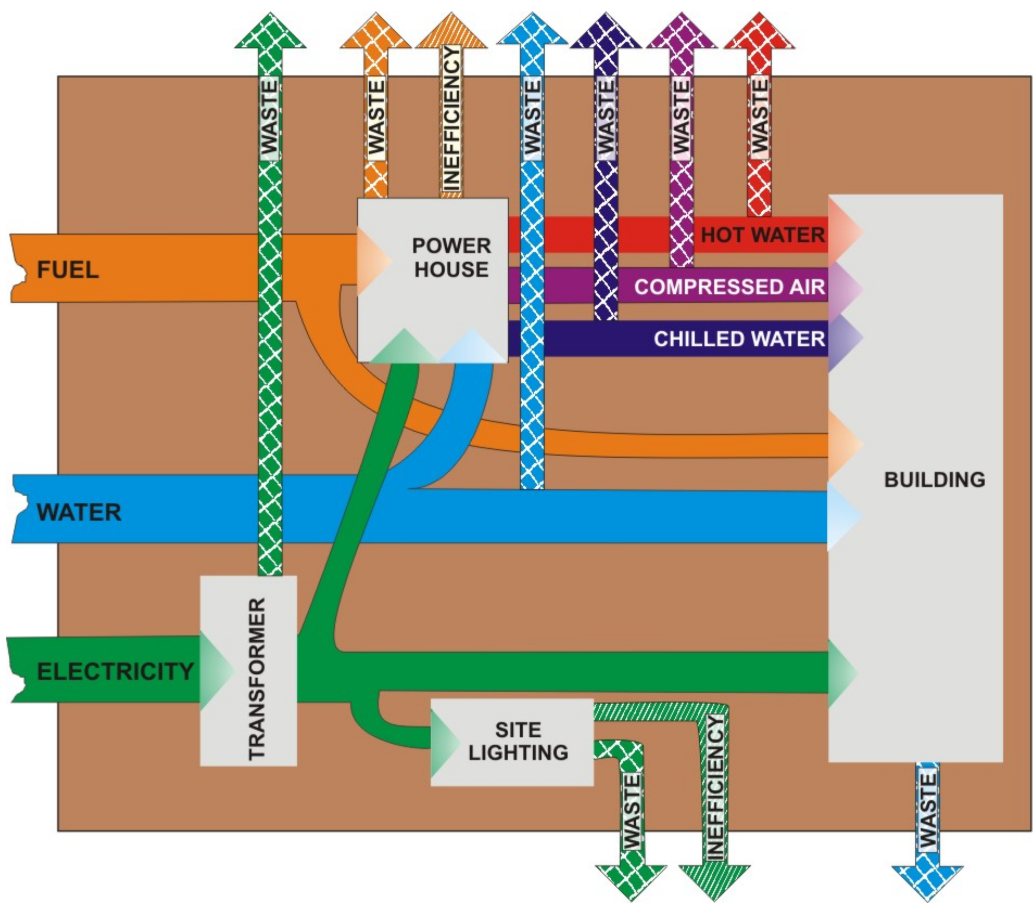

Figure 1. Example Sankey diagram of energy usage, waste, and inefficiencies for an Army installation.

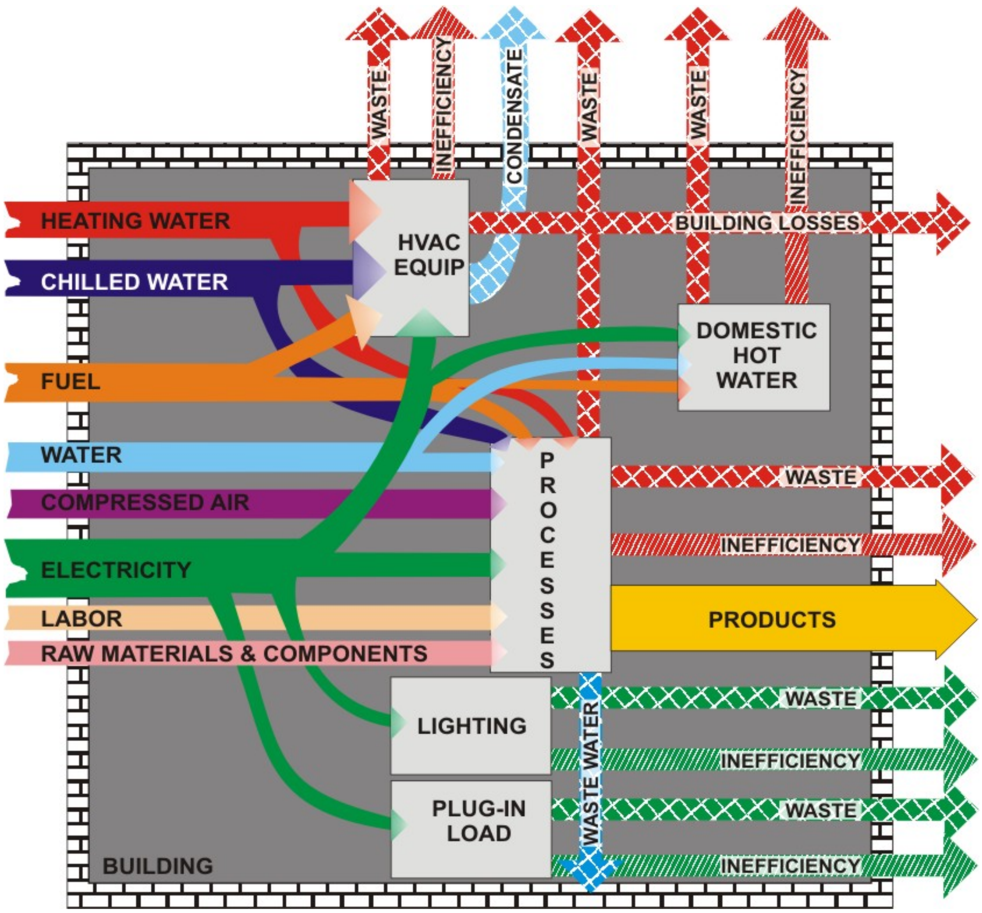

Figure 2. Example Sankey diagram of energy usage, waste, and inefficiencies for a building with production process.

The protocol addresses several different scopes (building stock, individual building, system, and component) and levels of assessment:

- Energy conservation opportunities analysis. This involves no instrumentation using basic analysis to generate a list of top energy saving ideas (Level 1).
- Energy optimization analysis geared toward funds appropriation. This calculates savings and uses partial instrumentation with cursory analysis (Level 2).
- Detailed engineering analysis with implementation, M&V. This includes performance measurement and verification assessment, and a fully instrumented diagnostic audit (Level 3).

Figure 3 shows the different levels of the energy audit scope.

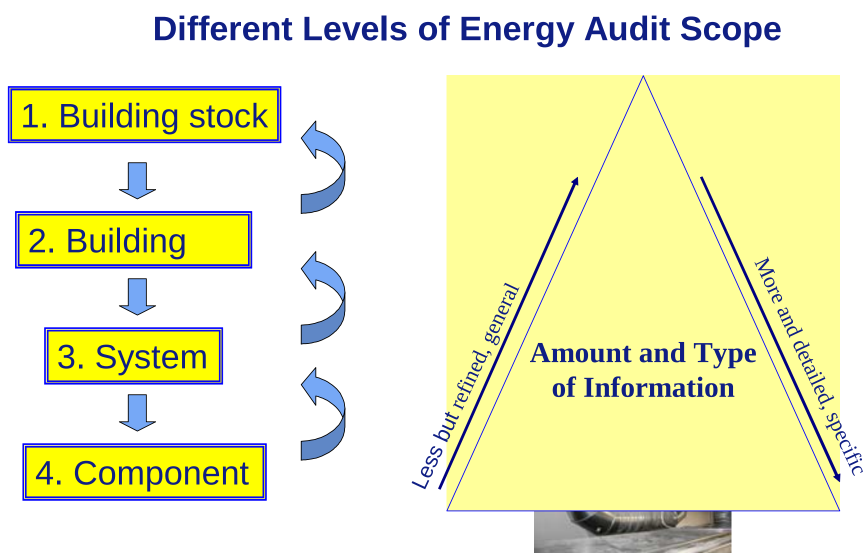

Figure 3. Different levels of energy audit scope.

The key elements that guarantee success of the energy assessment are:

1. Involvement of key installation personnel who know what the problems are, where they are, and have thought of many potential solutions;
2. The facility personnel sense of “ownership” of the ideas, that in turn develops a commitment of implementation; and
3. A focus on site-specific, critical issues, which if solved, will make the greatest possible economic contribution to an installation’s bottom line.

Scope

The scope of the Level I study included central energy plants and distribution systems at Fort Stewart and Hunter Army Airfield, several industrial and non-industrial buildings with the analysis of their building envelopes, ventilation, compresses air systems, lighting, and individual steam boilers to enhance operational performance and building energy systems and to improve the soldiers’ working and living environments. This study was one of a series of similar studies at selected Army installations to identify energy and performance improvement opportunities and workplace improvement strategies, and to collaborate with engineers and contractors to apply these strategies.

This Level I energy assessment evaluated industrial production processes and non-industrial facilities (i.e., barracks, dining facilities, operations facilities, etc.), central energy plants, and the building envelope, ventilation, compressed air systems, and corresponding boilers. This work assumes that technical solutions are possible and that economic calculations are approximations (accurate to ±40 percent). Only limited engineering measurements were made in both phases.

Mode of Technology Transfer

The results of this work will be presented to Fort Stewart, GA for their consideration in pursuing follow-on Level II work. It is anticipated that the results of this work will contribute to further awareness to the Installation Management Agency's (IMA) installations, as well as to Corps, District, and other Army installation personnel, via implementation through the associated regional IMA offices. It is also planned to disseminate this information through workshops, presentations, and professional industrial energy technology conferences. This report will also be made accessible through the World Wide Web (WWW) through URL:

http://www.cecer.Army.mil

2 CERL's Energy Assessment Methodology

The Energy Audit

A variety of energy and industrial assessment methodologies, protocols, and guides have been developed over the past years to improve energy efficiency of both private and government facilities. These audit tools have different emphases and thoroughness, which depends on the audit objectives and on the available human and financial resources.

The Energy Assessment Protocol developed by CERL in collaboration with a number of government, institutional, and private sector parties is based on the analysis of the information available from literature, training materials, documented and non-documented practical experiences of contributors, and successful showcase energy assessments conducted by a diverse team of experts at the U.S. Army facilities. The protocol addresses both technical and non-technical, organizational capabilities required to conduct a successful assessment geared to identifying measures that can reduce energy and other operating costs without adversely impacting product quality, safety, morale, or the environment.

Scope and Depth of Energy Audits

Energy audits are classified into three “levels.” These levels differ from each other in their objectives, scope, methodology, procedures, required instrumentation, and approximate duration:

- A *Level I* audit is a preliminary energy and process optimization opportunity analysis consisting primarily of a walk-through review. It takes from 2 to 5 days, and allows identification of the dollar potential for process improvements and energy conservation to the bottom-line. No engineering measurements using test instrumentation are made. Existing processes are challenged, and new practices and technologies are considered. A Level I audit would normally be followed by a Level II audit to verify the Level I assumptions, and to more fully develop the ideas from the Level I screening analysis.

- A *Level II* audit is an energy and process optimization analysis geared towards funds appropriation utilizing calculated savings and partial instrumentation measurements with a cursory level of analysis. The Level II study typically takes 5 to 10 times the effort of a Level I, and could be accomplished over a 2- to 6-month period, depending on the scope of the effort. The Level II effort includes an in-depth analysis in which all assumptions are verified. The end product will be a group of "appropriation grade" process improvement projects for funding and implementation.
- The *Level III* audit is a detailed engineering analysis with implementation, performance measurement and verification (M&V) assessment, and fully instrumented diagnostic measurements. This level takes 3 to 18 months to complete (Lin et al. 2004, p 3).

Target Audience

This Energy Assessment Protocol is developed to assist the following target groups of users:

- Facility Energy Managers and in-house energy assessment groups
- Companies providing energy assessment
- Universities conducting energy assessment
- Energy Service Performance Contractors.

The key elements that guarantee success of the Energy Audit are:

1. Involvement of *key facility personnel* who know what the problems are, where they are, and have thought of many potential solutions.
2. The facility personnel sense of "ownership" of the ideas, that in turn develops a commitment of implementation.
3. A focus on site-specific, critical cost issues, which if solved, will make the greatest possible economic contribution to a facility's bottom line. Major potential costs issues include:
   a. capacity utilization (bottlenecks)
   b. material utilization (off spec, scrap, rework)
   c. labor (productivity, planning & scheduling)
   d. energy (steam, electricity, compressed air)
   e. waste (air, water, solid, hazardous)
   f. equipment (outdated or state-of-the-art), etc.

From a strictly cost perspective, process capacity, materials, and labor utilization can be far more significant than energy and environmental concerns. All of these issues, however, must be considered together to achieve DOD's mission of military readiness in the most efficient and cost-effective way (Lin et al. 2004, p 2).

Requirements to an Energy and Process Auditing Team

Expertise in energy auditing is not an isolated set of skills, methods, or procedures; it requires a combination of skills and procedures from different fields. However, an energy and process audit requires a specific talent for putting together existing ways and procedures to show the overall energy performance of a building and the processes it houses, and how the energy performance of that building can be improved. A well-grounded energy and process audit team should have expertise in the fields of heating, ventilating, and air conditioning (HVAC), structural engineering, electrical and automation engineering and, of course, a good understanding of production processes.

Most of the knowledge necessary for energy audit is a part of already existing expertise. Designers, consultants, contractors, and material and equipment suppliers should be familiar with the energy performance of the *specific* field in which they are experts. Structural designers and consultants should be familiar with heat losses through the building shell and what insulation should be added. Heating and ventilation engineers should be familiar with the energy performance of heating, ventilation, compressed air, and heat recovery systems. Designers of electrical systems should know energy performance of different motors, VFD drives and lighting systems. An industrial process and energy audit requires knowledge of process engineers specialized in certain processes.

Critical to any energy and process audit team member is the ability to apply an "holistic" approach to the energy sources and sinks in the audited target (installation, building, system, or their elements), and the ability to "step outside the box." This ability presumes a thorough understanding of the processes performed in the audited building, and of the needs of the end users. For this reason, the end users themselves are important members of the team. It is critical for management, production, operations and maintenance (O&M) staff, energy managers, and on-site contractors to "buy-in" to the implementation by participating in the process, sharing their knowledge and expertise, gathering information, and developing ideas.

Scope and Levels of an Audit

Depending on its target, an audit may include different components and activities. In a small office building or maintenance shop, the activities and the objectives will be different that those in a complex industrial building. The audit's objectives, available financial and human resources, documents and statistical information pertaining to the target (building, complex of buildings, etc.) will provide a framework for the auditing activities.

The main activities of energy and process audits include:

1. Collection of information and calculation of specific energy and water consumptions
2. Review of design and other technical documentations of the audited building
3. Review of manufacturing processes and uses of energy, materials, production costs and bottlenecks
4. Interviews with production and O&M personal and building occupants concerning productivity, thermal comfort, lighting level, and indoor air quality (IAQ).

An important part of the process and energy audit is the development of process and energy flow diagrams both into and out of the building or building complex, e.g., power and fuel supplied to the building/installation (input), building heating and cooling (outputs), fuel loss through handling, heat loss in distribution pipelines, heat loss in air compressors (energy waste).

The scope of the study described in this report was a Level I and limited Level II effort.

Preliminary Data Collection

Data collection prior to going to site will save time and money, and will also foster a partnership between the energy assessment team and the end-users. Early collection of the following data is desirable:

- master plan, building drawings, information on different shop areas, volume, occupancy patterns, typical building/shop usage, process layouts
- production hours for different areas/ shops, number of workers in each shift
- operation time for different processes
- any information on existing ventilation systems (layouts, airflows, controls, operation instructions)
- information on compressed air systems, boiler and chilled water plants, central child water and hot water/steam distribution systems
- heat and power prices (per unit)
- available information on energy use in recent years (electricity, oil, gas, etc.), site energy records of metered/sub-metered energy consumption, statistical data from the utility or/and bills, regarding electricity, oil, gas etc.
- total energy costs in recent years

- projected energy price increase (to be used in this project)
- key information related to production (number of units produced, use of raw materials, etc.) in different areas (past and the best estimates for the near and long-term future)
- recently completed energy improvement measures and results
- requirement to indoor air quality and thermal conditions in shops
- permits for exhaust air systems
- reports on recent studies (including ESCO proposals).

3 The Energy and Process Optimization Assessment at Fort Stewart, GA

Project Planning and Schedule

The assessment team was organized as shown in Figure 4. The FSG EPOA took place over a 12-day period between Monday, 18 July and Thursday, 28 July 2005. Figure 5 lists sub-teams assigned to the different process and energy system areas. Figure 6 shows how the 12-day assessment process was organized by time, activities, and location to ensure that all of the critical areas in the scope of work were covered and that the process of the information collection, brainstorming sessions, and briefings to the management were built-in to the FSG personnel busy schedules. The formal out-briefing to the Deputy FSG Garrison Commander was conducted on 28 July 2005.

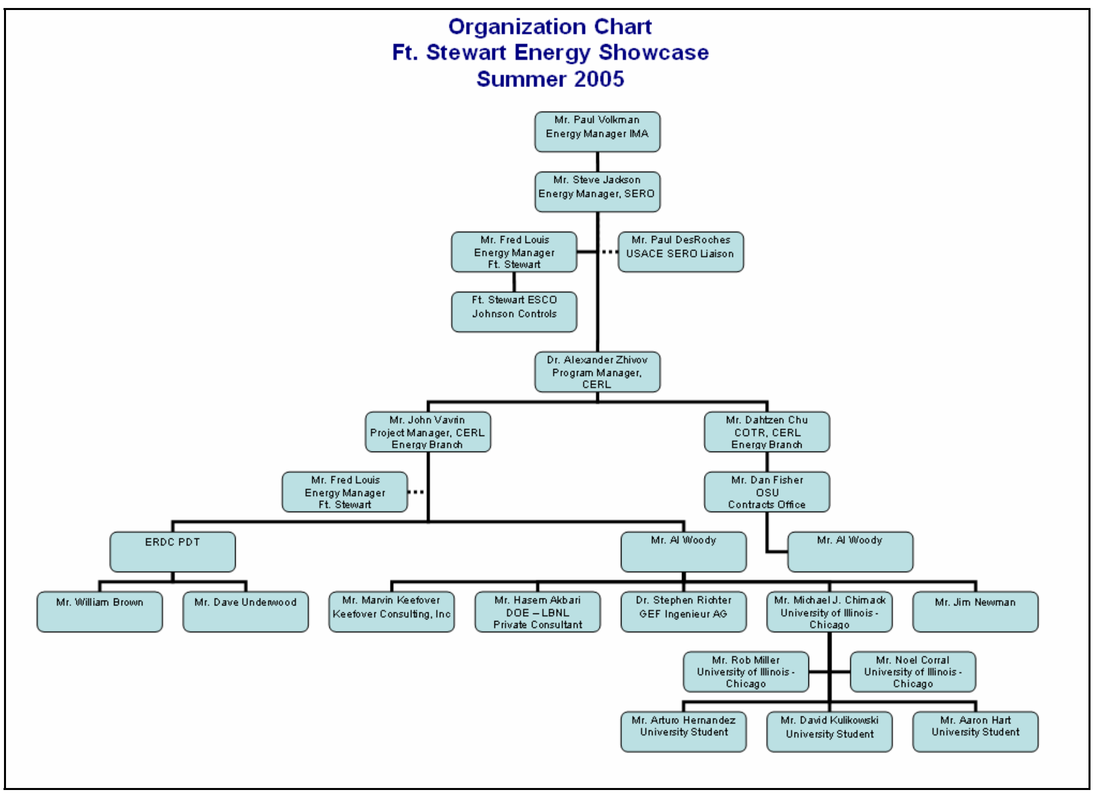

Figure 4. Organization chart for Fort Stewart Energy Showcase Assessment Team.

Team Assignments Ft. Stewart Energy Showcase 17 - 28 July 2005			
Team Black		**Team Grey**	**Team Gold**
Central Energy Plants [1]		**DOL Maint. Facilities, Unit Motor Pools** [2, 3]	**Barracks/Admin Facilities, DFAC/Training Facilities** [3]
Co-Lead - Rob Miller		**Lead** - Al Woody	**Lead** - Jim Newman
Marv Keefover		Marv Keefover	Marv Keefover
Alexander Zhivov		Alexander Zhivov	Alexander Zhivov
William Brown		Dave Underwood	John Vavrin
Co-Lead - Stephen Richter		Arturo Hernandez	Hashem Akbari
Noel Corral		David Kulikowski/Aaron Hart	
Facilities (Building Number)		**Facilities (Building Number)**	**Facilities (Building Number)**
350		***230***	100
1196/1197		***241***	212
1412	**CEP**	270/271	256
3001		***1160/1170***	405
HAAF:		1245	***608***
110	3.5 MMBtu, Dual	1265	620 - 623
1323	18 MMBtu, Dual	1320	632 - 639
1451	5 MMBtu, Gas	1340	***642 - 649***
1032	2.1 MMBtu, Gas	1620	712 - 715
8585	218 MMBtu, Oil	1630	720
1032	Size Unk	1720	810
1323	Size Unk	4502	5050
1451	Size Unk	4577/4578	5051
		DOL Modulars - various	

Team Members
Alexander Zhivov
John Vavrin
William Brown
Dave Underwood
Al Woody
Hashem Akbari
Marv Keefover
Jim Newman
Stephen Richter
Michael Chimack
Rob Miller
Noel Corral
Aaron Hart
Arturo Hernandez
David Kulikowski

Those facilities highligted in red and bold were reviewed by the ESCO for lighting and water, and HVAC controls. (See separate file of results)

Notes:
1. Includes: Hunter Army Airfield and Ft. Stewart
2. Includes: Painting, Welding, HVAC, Lighting, Compressed Air, General Maintenance
3. Inclusive is the building envelope

Figure 5. Sub-teams and assignments.

In 2004, FSG consumed:

- Electricity: 194,873 MWh (665,102 MMBtu)
- Natural Gas 152,590 KCF (157,320 MMBtu)
- No. 2 Fuel Oil 862,467 gal (119,616 MMBtu)
- Propane 129,182 gal (12,272 MMBtu)
- Waste Wood 66,753 short tons (600,777 MMBtu)
- Waste Oil: 107,814 gal (12,835 MMBtu).

The average costs during 2004 were:

- Electricity $0.045/kWh
- Natural gas $6.997/KCF
- No. 2 fuel oil: $0.948/gal
- Propane: $1.046/gal for
- Waste Wood: $14.829/ton
- Waste Oil: $0.510/gal.

Table 1 shows monthly consumptions and costs by fuel type during the 2004 calendar year.

Figure 7 shows the consumption breakdowns for each month; Figure 8 shows the cost breakdowns for each month. The data for the monthly consumptions and costs were obtained via the Army Energy and Water Reporting System through URL:

https://aewrs.hqda.pentagon.mil/aewrs/

			Team Black	Team Grey	Team Gold
Sunday	17-Jul				
		Flights In	Arrive at Hotel		
		~1800	Dinner & Introduction of Team Members		
Monday	18-Jul				
		0900 - 1000	In-Brief with DPW Staff, others to discuss: Objectives, Scope, Approach		
		1000 - 1200	Guided Tour of Ft. Stewart		
		1200 - 1300	Lunch		
		1300 - 1700	Distribution of Assignments & Begin Work		
			Team Black	Team Grey	Team Gold
		~1800	Dinner		
		1900 - 2000	AAR of days activities		
Tuesday	19-Jul				
		0900 - 1700	Team Black	Team Grey	Team Gold
		~1800	Dinner		
		1900 - 2000	AAR of days activities		
Wednesday	20-Jul				
		0900 - 1700	Team Black	Team Grey	Team Gold
		~1800	Dinner		
		1900 - 2000	AAR of days activities		
Thurdsay	21-Jul				
		0900 - 1700	Team Black	Team Grey	Team Gold
		~1800	Dinner		
		1900 - 2000	AAR of days activities		
Friday	22-Jul				
		0900 - 1400	Develop Preliminary Results and Prep for Out-Brief		
		1400 - 1500	Decision brief to DPW Staff on Initial Findings and Selection of Best Candidate Projects for ECIP		
		~1800	Dinner		

Figure 6. Detailed daily schedule for Energy Showcase Assessment.

Saturday	23-Jul				
		0800 - 1200	AAR of weeks activities and Begin Phase II		
		1200 - 1300	Lunch		
		1300 -	Personal Time		
Sunday	24-Jul				
		Personal Time			
Monday	25-Jul				
		0900 - 1700	Team Black	Team Grey	Team Gold
		~1800	Dinner		
		1900 - 2000	AAR of days activities		
Tuesday	26-Jul				
		0900 - 1700	Team Black	Team Grey	Team Gold
		~1800	Dinner		
		1900 - 2000	AAR of days activities		
Wednesday	27-Jul				
		0900 - 1700	Team Black	Team Grey	Team Gold
		~1800	Dinner		
		1900 - 2000	AAR of days activities		
Thursday	28-Jul				
		0900 - 1100	Develop Results and Prep for Out-Brief		
		1000 - 1200	Out Brief to DPW Staff on Findings of Best Candidate		

Figure 6. (Cont'd).

Table 1. Fort Stewart consumptions and costs by fuel type.

	Electricity			Natural Gas			#2 Fuel Oil			Propane		
Month	**MWH**	**MMBtu**	**Cost**	**KCF**	**MMBtu**	**Cost**	**Gal**	**MMBtu**	**Cost**	**Gal**	**MMBtu**	**Cost**
Jan-04	15,343	52,366	$645,786	20,237	20,864	$124,180	92,696	12,856	$80,644	41,003	3,895	$34,122
Feb-04	12,906	44,048	$530,034	20,156	20,781	$125,215	64,640	8,965	$56,235	22,226	2,111	$18,319
Mar-04	12,740	43,482	$527,873	12,389	12,773	$61,511	56,659	7,858	$49,292	14,239	1,353	$15,718
Apr-04	12,947	44,188	$537,883	9,936	10,244	$44,817	18,689	2,592	$16,260	3,081	293	$3,789
May-04	16,639	56,789	$665,797	9,581	9,878	$61,814	19,785	2,744	$17,210	1,566	149	$1,565
Jun-04	18,036	61,557	$804,989	7,789	8,030	$57,693	43,803	6,075	$38,111	2,221	211	$2,469
Jul-04	18,784	64,110	$968,446	8,274	8,530	$56,394	120,455	16,706	$104,797	3,732	355	$3,881
Aug-04	18,962	64,717	$1,059,909	8,633	8,901	$57,335	73,624	10,211	$64,055	2,990	284	$3,511
Sep-04	20,555	70,154	$842,413	8,379	8,639	$46,665	130,492	18,098	$113,530	2,515	239	$7,330
Oct-04	16,740	57,134	$769,686	8,276	8,533	$54,095	204,621	28,379	$235,318	3,431	326	$3,848
Nov-04	16,018	54,669	$692,077	14,678	15,133	$115,796	10,419	1,445	$11,978	13,366	1,270	$17,285
Dec-04	15,203	51,888	$667,253	24,262	25,014	$262,216	26,584	3,687	$30,574	18,812	1,787	$23,295
Total	*$8,712,146*	*665,102*	*$157,320*	*152,590*	*157,320*	*$1,067,731*	*862,467*	*119,616*	*$818,004*	*129,182*	*12,272*	*$135,132*

Table 1. (Cont'd).

	Wood			Waste Oil			Total (All Fuels)	
Month	**Short Tons**	**MMBtu**	**Cost**	**Gal**	**MMBtu**	**Cost**	**MMBtu**	**Cost**
Jan-04	4,730	42,570	$69,957	55,986	6,665	$28,553	139,216	$983,242
Feb-04	5,800	52,200	$85,782	25,578	3,045	$13,045	131,150	$828,630
Mar-04	6,970	62,730	$103,089	0	0		128,195	$757,483
Apr-04	6,553	58,977	$96,918	26,250	3,125	$13,388	119,419	$713,055
May-04	6,720	60,480	$99,388	0	0		130,040	$845,774
Jun-04	7,200	64,800	$106,488	0	0		140,673	$1,009,750
Jul-04	5,757	51,813	$85,146	0	0		141,514	$1,218,664
Aug-04	5,941	53,469	$87,867	0	0		137,582	$1,272,677
Sep-04	4,637	41,733	$68,581	0	0		138,863	$1,078,519
Oct-04	3,789	34,101	$56,835	0	0		128,472	$1,119,782
Nov-04	5,202	46,818	$78,030	0	0		119,335	$915,166
Dec-04	3,454	31,086	$51,810	0	0		113,462	$1,035,148
Total	*66,753*	*600,777*	*$989,891*	*107,814*	*12,835*	*$54,986*	*1,567,922*	*$11,777,890*

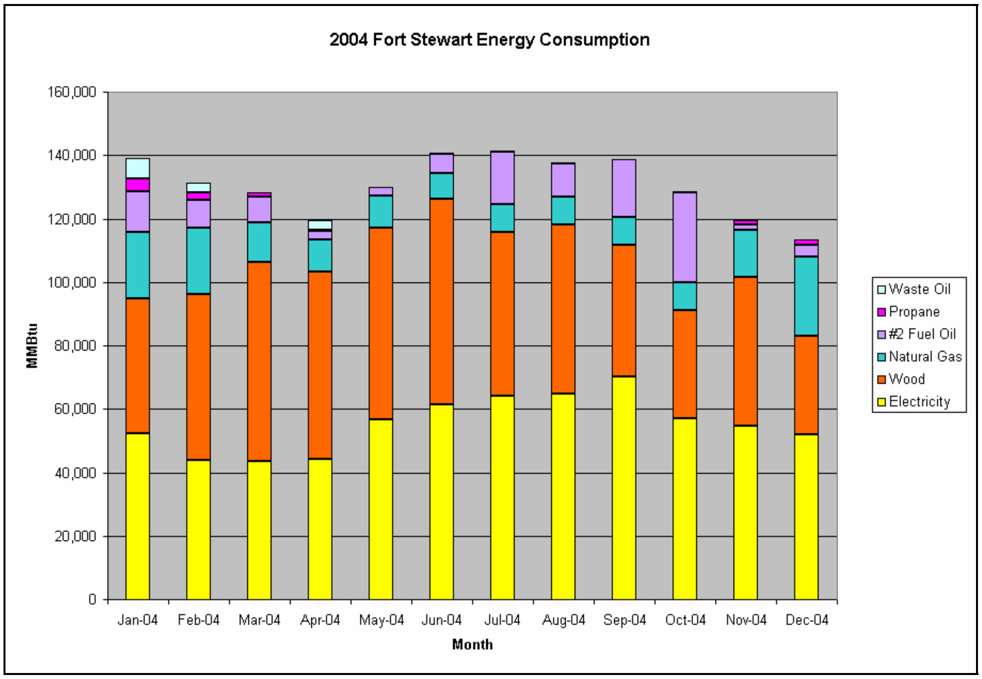

Figure 7. Fort Stewart energy consumption by fuel type – calendar year 2004.

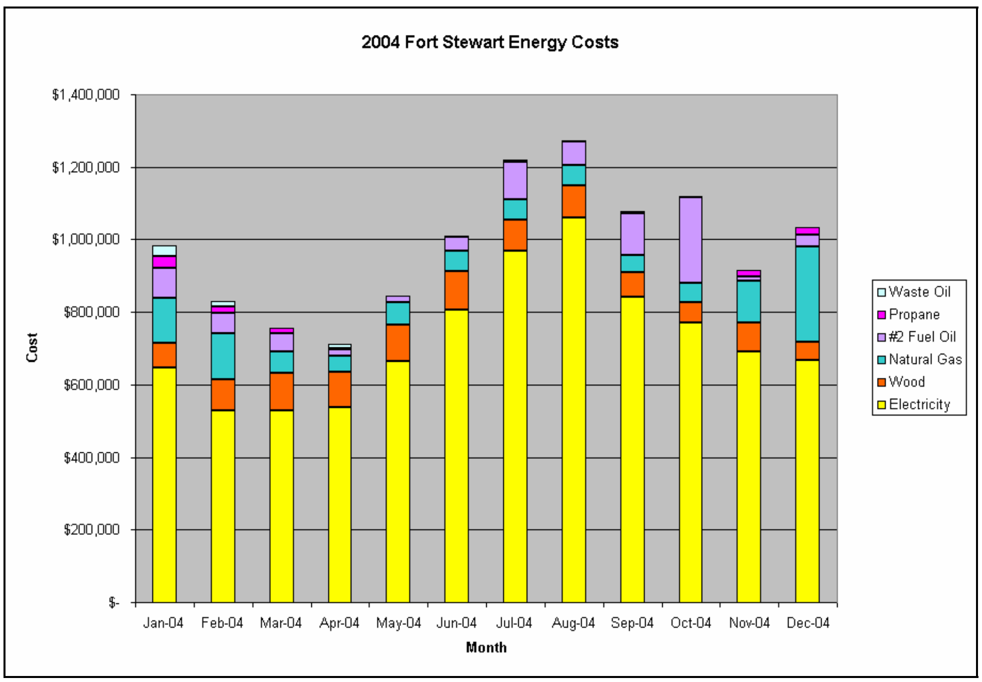

Figure 8. Fort Stewart energy costs by fuel type – calendar year 2004.

4 Fort Stewart Assessment Results

This chapter includes assessment results for the following systems:

1. Building Envelope (BE)
2. Compressed Air (CA)
3. Central Energy Plant (CEP)
4. Electrical (EL)
5. HVAC (HV)
6. Lighting (LI)
7. Motors (MO)

Energy Costs Used To Determine Results

Table 2 lists the energy costs (taken directly from the Johnson Controls ESCO proposal, 1 April 2005) used to determine economic results.

Table 2. Fort Stewart energy costs.

Fuel/ Energy	Cost/MMBtu
Wood	$2.09
Fuel Oil	$6.26
Natural Gas	$5.68
Waste Oil	$0.00
Total (Weighted Average)	$2.59
Electricity	$0.043/kWh
*Use for heat generation costs and savings.	

Projects Submitted for FY07 ECIP Consideration

One intermediate deliverable for this study was to develop FY07 ECIP submittals for Fort Stewart's DPW Office. Only projects with a Savings-to-Investment-Ratio (SIR) equal to or greater than 1.25 and a simple payback period of less than 10 years will qualify for ECIP consideration. During the first week of the on-site assessment, the study team developed potential ECIP project candidates. The team presented them to DPW leadership who, in turn, decided which projects would receive further refinement and analysis. Of the five projects selected, two met the standard for ECIP consideration:

1. Barracks dehumidification (simple payback of 4.92 years, SIR of 4.01) [ECM HV#6]
2. Install on-site cogeneration using both backpressure and steam condensing turbines – Central Energy Plant (simple payback of 6.61 yrs; SIR of 1.240) [ECM CEP#3]

The Appendix to this report outlines detailed life-cycle costs.

Building Envelope (Fort Stewart)

Assessment results for facilities regarding building envelope (Table 3) are documented by ECM.

Table 3. Evaluated facilities and ECMs for BE.

Facility	ECM	System Category
100	Properly commission HVAC units / Window film / Install automated building control systems / LED exit lights / Occupancy sensors to reduce lighting load / Install zone lighting capability (Auditorium)	BE
405	Coating on supply A/C ducts for more reflection	BE
Barracks	Spray foam insulation to underside of new roofs	BE
439	Spray foam insulation on ceiling for insulation from roof heat	BE
405	Change color of extended brown roof vertical surface to a lighter color	BE
516	Cool roofs	BE
4502 / 4578 / Post-Wide Maint Fac	Paint large metallic doors a more reflective color	BE
212 / 516	When rooms not in use, isolate space from outdoor air by blocking exhaust opening and shutting off supply air unit	BE

BE#1: Properly Commission HVAC Units; Window Film; Install Automated Building Control Systems; LED Exit Lights; Occupancy Sensors To Reduce Lighting Load; Install Zone Lighting Capability in Auditorium (Building 100 – Education Center)

Existing Conditions

Building 100 is within the 1-year construction warranty period. The HVAC systems consist of four air handling units serving separate floors and zones in a variable air volume (VAV) air supply system. The mixed air dampers on the air handling units are not operating properly, i.e., on a 93 °F day, the outside air dampers were almost fully open on at least 2 of the units, bringing in almost 100 percent hot, humid outside air when they should have been bringing in minimum outside air. The Ebtron sensors in the outside air stream were not reading the proper volume of outside air. Either proper commissioning was not done before the building was turned over to the Owner, or the damper linkages or mixed air sensors, as well as the Ebtron sensors, are not operating properly now.

The thermostats in empty rooms were set at 68 °F, forcing the VAV boxes to deliver 100 percent of design air to the rooms as if they were completely occupied. The combination of the two above items forces the chillers to operate at higher capacity for more time than necessary, thus using an excessive amount of energy.

Further, the lighting levels in the entire building are excessively high, especially in the corridors and the perimeter. The auditorium has only one light switch, in the floor beside the podium. There is no capability to reduce the light level during a power point presentation; the auditorium lights are either on or off. The classrooms have no occupancy sensors to change the temperature setpoint during unoccupied periods, or to turn off the lights.

It looks as though the Exit lights use standard lamps.

The building is designed with a high area of windows relative to the walls, contributing to excessive heat gains in the perimeter areas.

Solution

If possible, have the installing contractor commission (or recommission) the entire building to make sure the systems are operating as designed. If it is not possible to get the installing contractor to return, hire a commissioning agent to do this. *To maximize the energy savings, it is imperative that the HVAC system be operating properly*.

Zone the lighting around the perimeter both with additional switching and with light sensors, add additional switching to the lighting in the auditorium, and remove at least 50 percent of the fixtures from corridors and replace them with ceiling tile so corridors still have a pleasing appearance.

Change lamping in Exit signs to LED.

Add occupancy sensors in classrooms and offices.

Install a Building Automation System (BAS) so temperatures and light levels can be controlled in individual classrooms, HVAC systems can be watched and controlled properly, and light levels can be reduced at perimeter zones during sunny days.

Examine the efficacy of installing solar window film. Look at spectrally selective film rather than conventional to eliminate need for additional interior lighting at perimeter. This type of window film can also increase the productivity of building occupants through maximization of natural light, while at the same time reducing the temperature at the perimeter so people near the windows are more comfortable. While the increase in productivity is not shown in the "Savings" below, studies have shown that only a 2 percent productivity increase can pay for most energy savings measures in less than 2 years.

Savings

This work estimates a reduction in lighting energy in the corridors of 3kW, in the classrooms and auditorium of 4 kW, and in perimeter fixtures of 3kW, for a total of:

kWh/yr = 10 kW x 5 days/wk x 50 weeks/yr x 10 hrs/day = 25,000 kWh/yr.
At $0.043/kWh, savings = $1075.

There would be a commensurate reduction in maintenance hours required to replace lamps. These hours could be used to accomplish other tasks. In addition, the fixtures that would be removed from the corridors could be used elsewhere, and the lamps put into storage to reduce the relamping costs as lamps need to be replaced. The spare lamps would be used up by the end of year 2.

Replace standard lamps in Exit signs with LED lighting. The energy savings would be approximately $20/fixture at $0.043/kW, plus the replacement of the bulbs would be lessened by at least 80 percent, as the LED lamps have considerably longer life.

Proper installation of solar window film can reduce the transmission of solar energy through the glass by 50 to 55 percent.

The installation of a BAS could potentially save up to $7000/yr once the building HVAC systems are operating properly. This savings would be a combination of less energy consumed by the air handling unit fans, fewer filter changes and a much reduced load on the air-cooled chillers. *If the building continues to operate the way it is being operated now, the savings would be at least three times higher.*

Investment

Having the installing contractor return to properly commission the building should cost nothing, if commissioning was included in the contract. If not, the base might be able to have him return to fix improperly functioning damper operators, etc. as warranty items.

There might be a possibility of having the contractor remove the extra fixtures in the corridors at minimal or no cost, since this was a design-build project.

Adding occupancy sensors to the classrooms and offices is estimated at $5,000.

Zoning the perimeter and auditorium lighting, and removal of corridor fixtures is estimated at $8,000, while the installation of a simple BAS with minimal points is estimated at $35,000.

Installation of conventional window film is typically $4-6/installed sq ft; spectrally selective, $9-12 per installed sq ft.

Payback

The payback obviously depends on getting the HVAC systems to operate properly.

Assuming proper operation of the HVAC systems occurs at no cost by the installing contractor, and not including any solar window film of any type, the payback to change the lighting, add occupancy sensors and install the BAS is approximately 6 years. The increase in comfort levels in the classrooms and offices, however, would be instantaneous.

BE#2: Provide More Reflection Coating on Supply A/C Ducts (Building 405 – Community Club)

Existing Conditions

Surface temperatures of supply air ductwork that crosses the roof were measured from 120 to 128 °F, approximately 3o °F above the outdoor temperature.

Solution

A reflective white coating could be placed over the vinyl covered insulation to reduce the surface temperature by an estimated 25 °F. Also, coating of the ducts will fix all the small leaks. With a 100 sq ft duct surface having R-

2 duct insulation, 8 hours of peak sun, and 180 days of cooling per year will save 180 ton-hours of cooling per year.

Savings

180 ton hrs X 2 kWh/ ton hr = 360 kWh/yr

Cost savings = 360 kWh/yr X $0.0433/kWh = $15 / yr

Investment

Coating all the sides of a 2 ft by 50 ft long duct (about 400 sq ft) with white reflective would cost approximately $100.

Payback

The simple payback is 7 years.

The actual duct area would need to be identified to obtain funding for this project.

BE#3: Spray Foam Insulation to Underside of New Roofs (Barracks Facilities Only)

Existing Conditions

The non-modular barracks facilities (31 each) are approximately 30 years old and are renovated and repaired on a fairly routine basis due to mold, mildew and water damage. These maintenance and repair costs exceed $3.0 million annually. Moreover, metal pitched roofs (brown in color) were recently added to all barracks complexes to eliminate water damage and to protect HVAC systems. These new roofs protect approximately 365,000 sq ft of what was previously a flat roof. The total metal pitched roof area is approximately 421,500 sq ft. The new roof's outside temperature, on a typical sunny summer afternoon that is 93 °F dry bulb, exceeds 145 °F, and the shaded surface temperature of the old roof exceeds 106 °F.

Solution

To reduce the cooling load to these barracks, spray foam insulation on the underside of the pitched roofs. The underside of the roofs would decrease from about 144 °F to approximately 100 °F. The old roof's surface temperature would drop from 106 °F to the outside air temperature of 93 °F.

Savings

Savings accrue from reduced cooling through the underside of the ceiling. Roughly calculated annual savings is $40,300 at an electric rate of 4.3 /kWh.

Investments

The estimated investment for this ECM is $850,000. (This calculation was based on a previously used value ($2/sq ft) for the same type of service at another facility on post).

Payback

The estimated payback for this ECM is 21 years.

Note that the existing roof has approximately 6 in. of insulation, making this project uneconomical.

BE#4: Spray Foam Insulation to Underside of Roof (Building 439 – Newman Fitness Center)

Existing Conditions

The Newman Fitness Center, Building 439, was renovated in 2005 and incorporated was exterior roof insulation across the entire facility. The R value went from 5 to 18. The following were temperature measurements in July 2005: The temperature of the ceiling inside the gym area (at 93 °F dry bulb) was 68 °F. The supply air from the diffuser was about 60 °F; the return air temperature was 68 °F.

Solution

To reduce the cooling load through this facility's roof, spray foam insulation on the underside of the ceiling. The R value would increase from 18 to about 32 (with 2-in. of spray foam). The temperature of the ceiling inside the gym area (at 93 °F dry bulb) would drop from 68 °F to about 61 °F or 62 °F.

Savings

Savings accrue from a reduced cooling through the underside of the ceiling. Roughly calculated annual savings is $1,800 at an electric rate of 4.3¢/kWh.

Investments

The estimated investment for this ECM is $60,000. This calculation was based on a previously used value ($2/sq ft) for the same type of service at Fort Stewart at another facility.

Payback

The estimated payback for this ECM is 34 years.

Calculation Note

The Jordon Fitness Center cost was $18K for its gym area, at $2/sq ft.

BE#5: Change Color of Extended Brown Roof Vertical Surface to a Lighter Color (Building 405 – Community Club)

Existing Conditions

A review of the air conditioning units on the roof of this building noted that the roof over the ballroom was higher that the rest of the roof. This formed a short wall, which had been painted a dark color. Measurements showed the wall temperature was 156 °F (due to the dark color). This causes an increased load on the building's air conditioning units.

Solution

Paint this vertical surface with a more reflective paint the next time it requires painting.

Savings

A more reflective paint will reduce the surface temperature by an estimated 30 °F. It is assumed the 500 sq ft of vertical wall has 3 in. of insulation and therefore a "U" value of 0.1 Btu/hr per sq ft.

Cooling savings = 0.1 Btu/hr/ sq ft X 500 sq ft X 30 °F X 4 hrs/day X 180 days/yr = 1,080,000 Btu/yr

No. ton hrs = 1,080,000 Btu/yr/ 12,000 Btu/ ton hr = 90 ton hrs

kWh/yr = 90 ton hrs X 2 kW/ton hr = 180 kWh/yr

Cost savings = 180 kWh/yr X $0.0433 = $7.79/yr

Investment

The only cost for this project is the additional cost for the special paint which should be insignificant cost.

Payback

Because the cost is quite small, the payback should be less than 5 years.

BE#6: Cool Roofs (Building 516 – Barracks)

Existing Conditions

The new roofs for barracks and administrative buildings are a non-reflective coating and in the case of the barracks they are a brown color having a solar reflectance of about 10 percent. Measurements on the underside of the roof showed a temperature of 162 °F and the surface temperature of the floor of this attic space was measured to be 101 °F. From the drawings of the barracks it appears there is 6 in. of insulation in the original roofs (the floor of the attic).

Cool metal roofs of the same red color can have a solar reflectance of about 40 percent, reducing the roof's surface temperature by about 25 °F on sunny summer days. This in turn would reduce the attic floor temperature by a maximum of 10 °F.

Savings

R= 0.65 + 18+ 0.17 = 18.82

U = 1/R = 1/ 18.82 = 0.05

Q = 0.05 X 1 sq ft X 10F X 180 days/ yr X 8 hrs/day = 720 Btu/yr/ sq ft

This building has an estimated roof area of 8,784 sq ft.

Annual savings = 720 Btu/yr/ sq ft X 8784 sq ft = 6,324,480 Btu/yr

No. Ton hrs = 6,324,480 Btu/yr/ 12,000 Btu/ton hr = 527 ton hrs/ yr

kWh/yr = 527 ton hrs/ yr x 2 kWh/ton hr = 1054kWh / yr

Cost savings = 1054kWh / yr X $ 0.0433 = $41/yr

Investment

The only cost for this project is the additional cost for the special paint which should be insignificant cost.

Payback

Because the cost is quite small, the payback should be less than 5 years.

BE#7: Paint Large Metallic Doors a More Reflective Color (Building 4502, Building 4578, and Post-Wide Maintenance Facilities)

Existing Conditions

The maintenance facilities have overhead doors that open to provide access to every maintenance bay. Currently, these doors are painted to match the building color, but they could be painted with a more reflective paint to reduce the solar heat from the sun affecting the building temperature in the summer.

Solution

The next time the doors are painted use a paint formulation that has a greater reflectivity. The paint color may not need to change.

Savings

Since the maintenance buildings are not cooled during warm weather there is no energy savings. It is estimated the paint change will slightly reduce the building temperature (perhaps 1 or 2 °F). This will lead to more comfortable conditions for the building's occupants.

Investment

The only cost for this project is the additional cost for the special paint which should be insignificant cost.

Payback

Because the cost is quite small, the payback of any benefits for the improved summer comfort should be immediate.

BE#8: Stop Ventilation of Barracks Rooms When Not in Use (All Barracks)

Existing Conditions

The barracks are not occupied for several weeks a couple times a year when troops are elsewhere for training exercises, fulfilling mission requirements or other purposes. During this time the barrack rooms are supplied with dehumidified/tempered air and the spaces are also exhausted to provide an air flow through these spaces.

This ECM is to shut off the supply air unit and block off the exhaust air opening in the barracks bathroom when the troops leave the Post for extended time periods. After further review, these actions are not recommended due to the high humidity level experienced in the barracks. Flushing these spaces with dry air will help minimize any mold growth and moisture problems.

Compressed Air (Fort Stewart)

Assessment results for the maintenance facilities with compressed air, listed in Table 4, are documented by ECM.

Table 4. Evaluated facilities and ECMs for CA.

Facility	ECM	System Category
1073/1170/1265/1620/1630/4577/4578	Reduce compressor output pressure	CA
1073/1170/1265/1620/1630/4577/4578	Repair compressed air leaks	CA
4502 and 4577	Recover heat from compressors in buildings	CA

CA#1: Reduce Output Pressure of the Air Compressors

Existing Conditions

During the walkthrough of the maintenance facilities, many of the air compressors were not in operation due to the deployment of the unit. However the compressors that were found operating had high output pressures. The compressed air is used to operate pneumatic tools such as air wrenches. Pneumatic tools can usually operate at lower pressures than the pressures noted during the walkthrough. During the walkthrough it was noted that a typical compressor system consists of a 25 horsepower compressor with an output pressure of 110 psig.

Solution

Reduce output pressure of compressor by 10 psig. By reducing the pressure output of the compressor the compressor will need less electricity to operate.

Savings

Savings accrue by reducing the power draw of the compressor. It is calculated that a 4.5 percent reduction in the electrical energy consumption will occur by reducing the output pressure to 100 psig. The total cost savings for a typical compressor system is the $179. Similar savings can be expected from other compressors.

Investments

Reducing the output pressure requires only a few minutes; therefore the implementation cost associated with this recommendation is negligible. There is no investment cost for CA#1.

Payback

The payback for CA#1 occurs immediately.

Notes

The following buildings were surveyed and found to have air compressors with settings that can be adjusted per this recommendation: Buildings 1073, 1170, 1620, 4577, and 4578.

CA#2: Repair Compressed Air Leaks

Existing Conditions

During the walkthrough of the maintenance facilities, many of the compressors were not in operation due to the deployment of the unit. However the compressor systems that were operating were observed to have compressed air leaks. Based on previous experience and observation of compressor systems in maintenance facilities, it is estimated that 20 percent of the energy consumption by the compressors is lost to leaks. Based on volumetric flow calculations it is estimated that there are seven leaks associated with the system that was surveyed as part of the walkthrough.

Solution

Repair leaks in the compressor systems.

Savings

Savings accrue by the reduction in the power draw of the compressor. A typical compressed air system, found in the maintenance facilities, consists of a 25 horsepower reciprocating two stage compressor. The cost savings associated with the repair of all seven leaks found in the system surveyed is $702 per year.

Investments

Leaks usually occur in fittings and hoses. A leak can typically be repaired for $100. The estimated investment for CA#2 amounts to $700.

Payback

The estimated payback for CA#2 occurs in 1 year.

Notes

The savings are estimated for a typical compressed air system found in the maintenance facilities. However other compressors found in the facilities vary and thus savings will also vary.

The following buildings were surveyed and found to have air compressors with leaks that can be fixed per this recommendation: Buildings 1073, 1170, 1265, 1620, 1630, 4577, and 4578.

CA#3: Recover Heat From Compressors in Buildings 4502 and 4577

Existing Conditions

The heat off the compressors, in Buildings 4502 and 4577, is currently being exhausted to the atmosphere by a hood exhaust system. The storage area, located adjacent to the mechanical room, is currently heated by unit ventilators during the winter period.

Solution

Recover the heat from the compressor and route it into the storage area to supplement heating of the space during winter season. This will reduce the natural gas consumption used for heating.

Savings

Savings will occur due to the lighter load on the unit ventilators. The calculated savings for both of the buildings is:

Number of Buildings × Compressor Size × Recoverable Heat Percentage × Compressor Usage × Constant = Heat Recovered

$$2\times20HP\times0.746\frac{kW}{HP}\times0.80\times0.50\times3{,}412\frac{Btu}{kW\times hr}=40{,}726\frac{Btu}{hr}$$

$$\frac{\text{Hours of Heating}\times\text{Heat From Compressors}}{\text{Heating Units Efficiency}\times\text{Convertion Constant}}=\text{Natural Gas Savings}$$

$$\frac{3{,}600\frac{hr}{yr}\times40{,}727\frac{Btu}{hr}}{0.85\times1\times10^{6}\frac{Btu}{MMBtu}}=172MMBtu/yr\ ,$$

or 86MMBtu/yr if the compressors operate 50 percent of the time.

Natural Gas × Natural Gas Rate = Savings

86MMBtu/yr×$5.68/MMBtu = $488/yr

Investments

The installation of ductwork, dampers, and controls will be needed to recover heat during winter. Based on previous recommendations, it is estimated that installation will cost $1,500 per building. The estimated investment cost for CA#1 is then $3,000.

Payback

The estimated payback for CA#3 occurs in 6.1 years.

Notes

During the summer months the heat from the compressors will be exhausted to the atmosphere through louvers. Other compressors located in different facilities might be good candidates if the sizes and operating hours of the compressors are similar or longer to those presented above.

However this could not be determined because normal operating hours were not observed during the walkthrough of other buildings.

Central Energy Plants (Fort Stewart and Hunter Army Airfield)

Table 5 lists assessment results for the Central Energy Plant facilities.

Table 5. Evaluated facilities and ECMs for CEP.

Facility	ECM	System Category
1412	Foundation and drainage for woodchip pile for CEP (no overhead cover)	CEP
1412	Optimize heat exchanger use	CEP
1412	Install on-site cogeneration using both backpressure and steam condensing turbines	CEP
1412	Install on-site cogeneration using backpressure turbine	CEP
1412	Install on-site cogeneration using steam condensing turbine	CEP
1412	Reduce temperature levels in the district heating system	CEP
1277 - HAAF	Replace boilers with the one unit currently in storage	CEP
1323 - HAAF	Install Square D controls overheating on cooling tower, replacing Siemens controls	CEP
1324 - HAAF	HW reset based on hourly loads, control return water and supply water temp (operations project, no cost)	CEP

CEP#1: Foundation and Drainage for Woodchip Pile

Existing Conditions

The wood-fired boiler at the Fort Stewart Central Energy Plant (CEP) burns waste wood material, which is a combination of bark, sawdust, and chips. The average moisture content of waste wood is 50 percent (dry basis), which reduces the heating value of the wood. The waste wood rests as a pile on the ground, uncovered, without any platform or overhang. Up to 1 ft from the bottom of the woodchip pile, there is considerable dampness and moisture due to the high water table. Additionally, sand is mixed in with the woodchips, which can further reduce the heating value of waste wood. The CEP burns 55,000 to 65,000 tons (dry weight) of wood per year.

Solution

Provide a foundation and drainage for woodchip pile with no overhead cover.

Savings

Savings accrue from reduction of moisture content of the woodchip fuel supply from 50 to 35 percent (dry basis), which translates to a reduction of 9,750 tons/yr in wet weight. Roughly calculated savings are $176,335 at a rate of $14.00/ton.

Investment

The estimated investment for CEP#1 amounts to $349,420, based on a 9-in. concrete ground slab area of approximately 25,000 sq ft and multiple medium-duty floor drains.

Payback

The estimated payback for CEP#1 1s 2 years.

CEP#2: Optimize Heat Exchanger Use

Existing Conditions

The CEP consists of four boilers: the wood chip boiler with a capacity of 94,900 lb/hr steam output. In addition, three dual fuel natural gas/oil boilers are installed as backup.

Currently the wood chip boiler provides about 85 percent of the total heat load per year. The steam is used in three parallel cascade heat exchangers to heat up the hot water distributed in a high temperature hot water (HTHW) District Heating (DH) system. Furthermore, a share of steam is used as heat source for two absorption chillers that are connected to a district cooling system, which is supplied by two electrical chillers as well. Currently the entire chilled water demand is supplied by those electrical chillers since the absorption chillers are shut down and will be replaced by two new two-stage absorption chillers.

Since the moisture content of the wood chips amounts to 50 percent, the flue gas has a high moisture content as well. The flue gas temperature is between 350 and 400 °F while the mass flow amounts to 78,000 lb/hr. The enthalpy of the moisture in the flue gas amounts to 1,217 kBtu/lb.

The CEP team consists of 19 staff members, including 13 operators. The CEPs are operated manually; at least 1 worker is on site at all times.

Besides two planned shutdowns per year, four to five unexpected shutdowns occur with a mean downtime of about 4 to 5 days. If required, the dual fuel boilers can go on-line within 15 or 20 minutes.

Solution

Install a waste heat economizer to recover waste heat from the flue gas. Since the bulk of fuel are wood chips (85 percent) with a moisture content up to 50 percent volume, the flue gas has a high moisture content as well. The flue gas has a high enthalpy due its moisture content and high temperature (about 390 °F). An easy way to employ the waste heat from the flue gas is to install a heat exchanger in the stack or (better) in the incoming pipe. For example, the recovered heat can be used to preheat the return water of the DH system. Figure 9 shows such a heat exchanger.

The upper temperature boundary is given by the flue gas temperature. The lower boundary is given by the temperature which is required to ensure self-contained draw-off strength. This temperature is at about 250 °F, which leads to a ΔT of about 140 °F, which, when transferred to the return water in the DH system can heat up from 167 to 212 °F. This equals a mass flow of about 180 gal/min (gpm) (41 m^3/hr).

Savings

The dimension of the required heat exchanger results from the equation:

$$Q = \dot{m} \times H \times \Delta T \times t$$

where:

Q	=	heat energy
$\dot{m}$	=	flue gas mass flow in = 78,000 lb/hr = 35.4 metric tons/hr
H	=	enthalpy = 0.27 Btu/(lb °F) = 1.13 kJ/(kg·K)
ΔT	=	temperature difference = 144 °F = 80 K
t	=	useful hours per year = 80%/yr = 7,000 hr/yr.

With the specified numbers, the installed capacity of such a heat exchanger should amount to 900 kW (with a 4-in. pipe: 41 m^3/h = 180 gpm). Since the wood chip boiler supplies the current steam demand for 85 percent of the year, an annual utilization of 80 percent or 7,000 hours is assumed. Thereby the recoverable heat amounts to approximately 6,300 MWh/yr or 21,500 MMBtu/yr. This heat energy can be used to preheat the DH return water as well for a preheating of the make-up and feed-in water if the design temperature fits and the temperature boundaries are met.

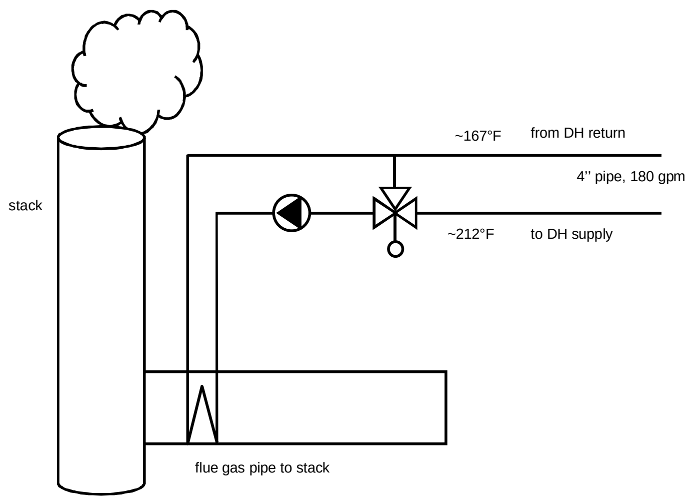

Figure 9. Schematic drawing of a waste heat-recovering heat exchanger for the flue gas.

Investment

Installing the economizer or waste heat recovering heat exchanger in the flue gas for a 1-MW heat exchanger is expected to cost about $129,000 for the heat exchanger itself and an additional $29,000 for piping and control systems. Therefore the total investments for the heat recovery installation from the flue gas amounts to $158,000.

Payback

The estimated payback for CEP#2 occurs in 2.8 years without interest (without mounting).

CEP#3: Install On-Site Cogeneration Using Both Backpressure and Steam Condensing Turbines

Existing Conditions

Refer to CEP#4 and CEP#5 for the existing conditions of this ECM.

Solution

This ECIP Project includes the installation of a backpressure turbine and condensing turbine to generate electricity. The pressure of Boiler #4 would be increased to 700 psig and the steam flow would also be increased by 50,000 lbs/hr.

Savings

Calculated savings from CEP#3 are $369,562.

Investments

The required investment would be $2,442,228.

Payback

The calculated payback period would be 6.61 yrs; SIR 1.24

CEP #4: Install On-Site Cogeneration Using Backpressure Turbine

Existing Conditions

Currently, the Fort Stewart CEP produces steam to supply hot water to the base hospital, dining facilities, and barracks. The CEP also produces steam for the plant's absorption chillers, which are used to cool buildings on base. Boiler 4 handles the majority of the yearly steam load. Boiler 4 is a wood fired boiler that runs approximately 7,800 hours per year. Boiler 4 operates at an average pressure of 186 psig with an approximate steam flow rate of 34,000 lbs/hr. Under these conditions, Boiler 4 consumes 4.7 tons of wood per hour. Boiler 4 was designed to operate at a maximum pressure of 850 psig and a maximum steam flow rate of 94,000 lbs/hr. Currently Boiler 4 provides approximately 34,000 lbs/hr of steam in the heating season and approximately 21,000 lbs/hr of steam in the cooling season at a pressure of 189 psig.

Under current operating conditions Boiler 4 operates at less than 25 percent of the rated load. Boiler 4 is far less efficient than average because it is lightly loaded. This decrease in efficiency occurs, in part, because fixed losses are magnified under lightly loaded conditions. This light load results in increased maintenance and downtime for the boiler.

Solution

Based on the maximum allowable pressure of Boiler 4 and the steam flow rate required by Fort Stewart, it has been determined that a backpressure turbine can be installed to generate electricity. This cogeneration system will provide both heat and power to Fort Stewart. The current operating pressure of 186 psig will be increased to 700 psig for the backpressure turbine to operate. Figure 10 shows a diagram of a boiler system working in tandem with the backpressure turbine.

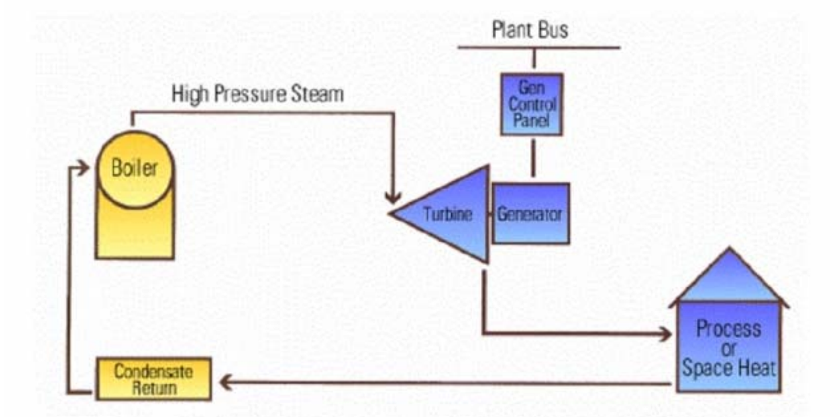

Figure 10. Backpressure turbine system.

After consulting an industry vendor, given the steam flow rate of 34,000 lb/hr and a proposed operating pressure of 700 psig, it was determined that a 500 kW backpressure turbine will be optimal. Steam will be generated at 700 psig and then be immediately put through the turbine, which will generate electricity while at the same time reducing the pressure to approximately 185 psig. Since the pressure and temperature of the steam remains the same as it leaves the plant, no changes will have to be made in the valves or heat exchangers of the steam distribution system. The current operating conditions for the end users of the steam will remain the same. The turbine will be installed in the CEP and will not require any additional construction.

The turbine will generate electrical energy at a cost of $0.020/kWh, as compared to the current purchase rate of $0.043/kWh. The difference in pricing results from the low cost of the wood chips used to power Boiler 4. There will most likely be an associated demand reduction in addition to the energy decrease, but the pricing structure of Fort Stewart's electrical utility precludes an accurate analysis of these savings.

Georgia is home to 27 pulp and/or paper mills that produce more paper and paperboard than any state except Alabama. Georgia's pulp and paper mills ship $10 billion in pulp and paperboard products worldwide, and the state leads the nation with 24 million acres of commercial forests. Timber is also Georgia's highest valued agricultural product. Increasing market demand for paper and paper products, along with the nearness of the resource, indicate that wood chips will remain a viable and low cost source of fuel for the foreseeable future.

In addition to electrical energy savings, there are other benefits that accompany cogeneration. One such benefit is energy security. With installation of the backpressure turbine, Fort Stewart will be able to generate 3,900,000 kWh of electricity per year. This represents 2.1 percent of the total electricity consumption of the base. Installing the backpressure turbine will help ensure availability and reliability of power for mission requirements, resulting in a secure, survivable, and sustainable source of electricity for Fort Stewart.

Required maintenance of the backpressure turbine can be performed at the same time that maintenance on Boiler 4 is being performed. This will minimize downtime of the turbine and also ensure consistent, dependable generation of electricity.

Savings

Increasing the pressure of Boiler 4 will require a corresponding increase in the amount of wood needed to operate Boiler 4 by 5,499 tons/yr. At $14/ton, this will result in a cost increase of $76,986/yr. According to the base energy engineer, the cost increase associated with operation and maintenance is 5 percent of the total purchase and installation cost of the turbine, which equals $23,800. The total annual electrical energy savings for this recommendation is 3.9 million kWh/yr with a cost savings of $167,700/yr. The total annual cost savings per year is then $67,084/yr.

Investments

The cost of implementing this recommendation is the cost of the backpressure turbine itself and the cost to have it installed. After consulting an industry vendor, it was concluded that a backpressure turbine that will generate 500 kW of electricity will cost $280,000. It was also determined that the installation of a backpressure turbine will cost $196,000. Currently, one of the boiler technicians in the CEP has previous experience working with turbines. Training for CEP personnel on the operation and maintenance of the backpressure turbine is included in the installation cost of the turbine. A contingency of 5 percent of the total purchase and installation cost is taken into account, which equates to $23,800. This brings the cost of implementation to $499,800. Overhead costs were also estimated to amount to 5.7 percent of the cost of implementation, or $28,489. The total implementation cost for this recommendation is then $528,289.

Payback

The savings of $67,084/yr will pay back the implementation cost in 7.9 years.

CEP #5: Install On-Site Cogeneration Using Steam Condensing Turbine

Existing Conditions

Currently, the Fort Stewart CEP produces steam to supply hot water to the base hospital, dining facilities, and barracks. The CEP also produces steam for the plant's absorption chillers, which are used to cool buildings on base.

Boiler 4 handles the majority of the yearly steam load. Boiler 4 is a wood fired boiler that runs approximately 7,800 hours per year. Boiler 4 operates at an average pressure of 186 psig with an approximate steam flow rate of 34,000 lbs/hr. Under these conditions, Boiler 4 consumes 4.7 tons of wood per hour. Boiler 4 was designed to operate at a maximum pressure of 850 psig and a maximum steam flow rate of 94,000 lbs/hr. Currently Boiler 4 provides approximately 34,000 lbs/hr of steam in the heating season and approximately 21,000 lbs/hr of steam in the cooling season at a pressure of 189 psig.

Under current operating conditions Boiler 4 operates at less than 25 percent of the rated load. Boiler 4's efficiency is far less than average because it is lightly loaded. This decrease in efficiency occurs, in part, because fixed losses are magnified under lightly loaded conditions. This light load results in increased down time for the boiler as well as increased maintenance.

Solution

Based on the maximum allowable pressure of Boiler 4 and the steam flow rate required by Fort Stewart, it has been determined that a steam condensing turbine can be installed to generate electricity. This cogeneration system will provide both heat and power to Fort Stewart. The current operating pressure of 186 psig will be increased to 700 psig and the flow rate of steam increased by 50,000 lbs/hr to 84,000 lbs/hr for the condensing turbine to operate. Figure 11 shows a diagram of a boiler system working in tandem with the steam-condensing turbine.

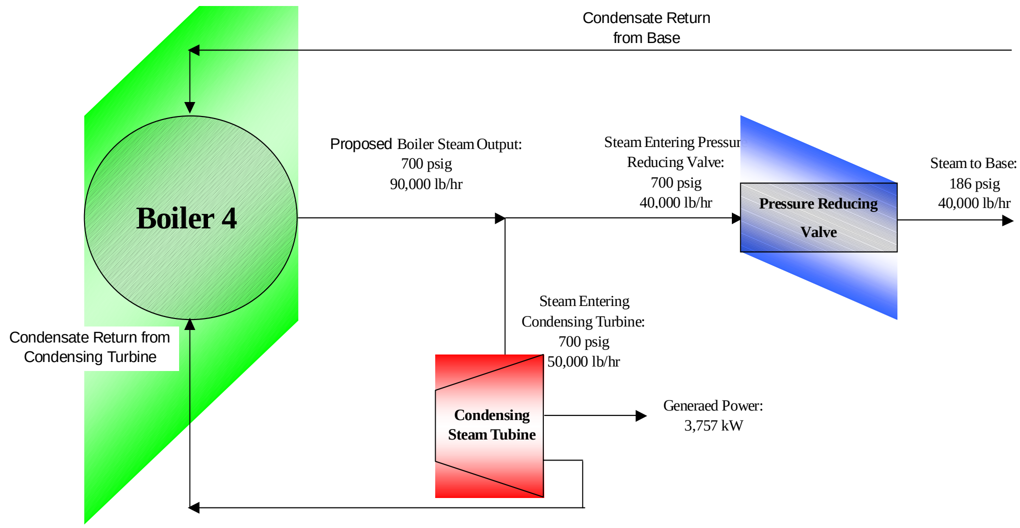

Figure 11. Condensing steam turbine system.

After consulting an industry vendor, given the steam flow rate of 84,000 lbs/hr and a proposed operating pressure of 700 psig, it was determined that the condensing turbine will generate 3,757 kW. Steam will be generated at 700 psig; 50,000 lbs/hr of steam will supply the condensing turbine and the remaining flow rate of 34,000 lbs/hr will supply the various zones on Fort Stewart. Note that a super-heater will not be required for this recommendation because the recommended turbine utilizes saturated steam to operate.

To ensure that the current operating conditions for the end users of the steam will remain the same, a PRV will be installed on the steam distribution system before it leaves the CEP. The pressure-reducing valve will reduce the pressure of the steam from 700 psig to approximately 185 psig. Since the pressure and temperature of the steam as it leaves the Central Energy Plant will remain the same in the new configuration as in the old, no changes will have to be made in the valves or heat exchangers of the steam distribution system. In addition to a PRV, a steam condenser and a 30 hp pump must be purchased to condense the exhausted steam from the turbine and return it to the boiler.

The turbine will generate electrical energy at $0.0322/kWh, as compared to the current purchase rate of $0.043/kWh. The difference in pricing results from the low cost of the wood chips used to power Boiler 4. There will most likely be an associated demand reduction in addition to the energy decrease, but the pricing structure of Fort Stewart’s electrical utility precludes an accurate analysis of these savings. (It is anticipated that wood chips will remain a viable and low cost source of fuel for the foreseeable future.)

In addition to electrical energy savings, there are other benefits that accompany cogeneration. One such benefit is energy security. With installation of the condensing turbine, Fort Stewart will be able to generate 29,304,600 kWh of electricity per year. This represents 16 percent of the total electricity consumption of the military base. This will help ensure availability and reliability of power for mission requirements, resulting in a secure, survivable, and sustainable source of electricity for Fort Stewart.

Required maintenance can be performed on the steam-condensing turbine at the same time that maintenance on Boiler 4 is being performed. This will allow for the steam-condensing turbine to operate in conjunction with Boiler 4. This will minimize downtime of the turbine and also ensure consistent, dependable generation of electricity.

Savings

Increasing the pressure of Boiler 4 will require a corresponding increase in the amount of wood needed to operate Boiler 4 by 67,498 tons/yr. At $14/ton, this will result in a cost increase of $944,972/yr. According to the base energy engineer, the cost increase associated with operation and maintenance is 5 percent of the total purchase and installation cost of the turbine, which equals $88,787. A 30 hp pump must be installed to return the condensed steam back to the boiler; this will increase electrical energy consumption by 176,251 kWh/yr. The net annual electrical energy savings for this recommendation is 29,128,349 kWh/yr with an associated cost savings of $1,261,258/yr. The total annual cost savings per year is then $227,499/yr. Energy savings calculations for the installation of the turbines were carried out using the energy generated, 3,757 kW, multiplied by the annual hours of usage. Energy increase calculations for the 30 hp pump were done using a simple energy usage equation, which takes into account the motor horsepower, annual operating hours, load factor, and motor efficiency. Finally, the net annual energy savings were found by subtracting the energy increase from the energy savings.

Investments

The cost of implementing this recommendation is the cost of the steam-condensing turbine itself and the cost to have it installed. After consulting an industry vendor, it was determined that a steam condensing turbine that will generate 3,757 kW of electricity will cost $1,066,000, including installation. Currently, one of the boiler technicians in the CEP has previous experience working with turbines. In addition to this, training for CEP personnel on the operation and maintenance of the steam-condensing turbine is included in the installation cost of the turbine.

To maintain the current steam pressure, a PRV will be installed. The cost of a pressure-reducing valve is $220,000, including installation charges. A steam condenser would also be required to condense exhausted steam from the turbine. After consulting an industry vendor, it has been determined that a steam condenser will cost $428,890 including installation and a 30 hp pump will cost $10,221 including installation. A new building must be constructed to house the condensing steam turbine. It has been determined that the building must have dimensions of 25 x 25 ft and will cost $50,625 to construct (Richardson Engineering Services 2001). A contingency of 5 percent of the total purchase and installation cost of the turbine and building is taken into account, which equates to $88,787. This brings the cost of implementation to $1,864,523. It was also estimated that overhead costs would amount to 5.7 percent of the cost of implementation, which equates to $106,278. The total implementation cost for this recommendation is then $1,970,801.

Payback

The savings of $227,499/yr will pay back the implementation cost in 8.66 years.

Notes

In addition to the steam-condensing turbine, Fort Stewart has the option of installing a backpressure turbine instead of a pressure-reducing valve. If a backpressure turbine is installed in addition to the steam-condensing turbine, the total annual electrical energy savings for this recommendation is 33,028,349 kWh/yr with an associated cost savings of $385,197/yr. The investment cost for the steam condensing and backpressure turbines then increases to $2,453,320, resulting in a payback of 6.37 years. Figure 12 shows a diagram of a boiler system working in tandem with both the steam condensing and backpressure turbines.

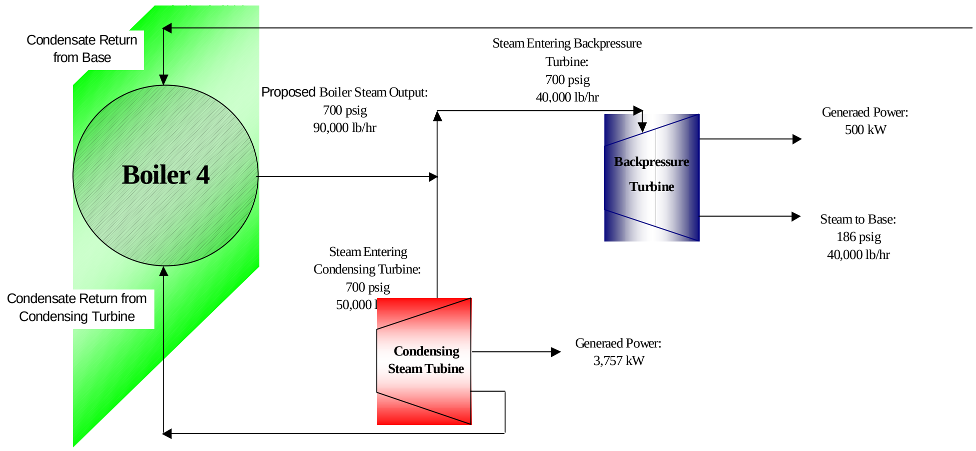

Figure 12. Combined turbine system.

CEP #6: Reduce Temperature Levels in the District Heating System

Existing Conditions

The CEP consists of four boilers: a wood chip boiler with a capacity of 94,900 lb/hr steam output and three dual fuel natural gas/oil boilers, which were installed as backup. It is from this plant many of the buildings at Fort Stewart receive their heat. The CEP provides 380 °F water to the installation's underground pipe distribution system. The return temperature is 240 °F. The piping is currently being replaced to minimize water loss due to leaks and heat loss due to poor insulation. Even after the new pipes are installed heat from the pipes will be lost to the surrounding ground.

Energy could be saved by reducing the hot water temperature during the non-heating season. The main energy users are:

- The hospital
- Installation Dining facilities (DFACs)
- DHW in various buildings
- Space heating in various buildings.

All energy uses are needed throughout the year except space heating. The hospital and post dining facilities require a higher temperature hot water that the other users. These uses include sterilization at the hospital (requires 300 °F) and cooking and dishwashing in the DFACs (requires 270 °F). The required temperature for space heating and domestic hot water preparation is less and varies through the seasons of the year. Their demand depends on the outdoor temperature as will as on the daily peaks for domestic hot water use (e.g., taking shower etc.).

Solution

A control system to reduce the hot water temperature could be installed if the high temperature requirements were removed. Smaller local steam boilers can be installed at the hospital and the DFACs. This will remove the requirement to distribute 380 °F water. The converters located in each building become the next limiting factor as to how much the hot water temperature can be reduced. All of the converters could be replaced, but that would be quite costly. It is suggested that further analysis and some building specific experimentation take place to determine the optimum low hot water temperature during the non-heating season.

Savings

Based on experiences of similar facilities the lowest estimated hot water temperatures are 167 °F supply water and 131 °F return water. These temperatures would increase as the outside temperatures drops below 50 °F. The resulting 69,100 million BTU per year has a cost avoidance of $179,000 per year.

Investment

The cost for the hospital's and DFACs boilers is $400,000. An additional $300,000 would be for controls that would measure the hot water needs and vary the temperature accordingly. To replace the converters in the buildings would require an investment of at least $1.5 million. The total of these values is approximately $2.2 million.

Payback

The payback with replacing all the converters is 12.3 years. The payback with no converter replacement would be less than 4 years. If a program was instituted to reduce the temperature only to the point where only a few converters would be required a favorable payback should be obtained. To determine how low this temperature would be requires additional evaluations. Appendix B provides a detailed discussion presented by Dr. Stephan Richter on seasonal temperature reduction of HTHW that is closely related to CEP#6.

CEP #7: Replace Boilers in Storage (Hunter AAF Building 1277) with a Leased Mobile Boiler

Existing Conditions

At the time of the assessment, two of the three boilers in Building 1277 were providing steam to three barracks on HAAF. Originally, the three boilers supported many more buildings on the base, and were sized to do so, but the number of buildings has been reduced as older barracks were torn down and their newer replacements were added to other steam loops on the base. Now the boilers support only two barracks, as the third barracks has been torn down and no new loads have been added. The two boilers are now operating at 1/3 of their design load.

Most boilers are designed to achieve maximum thermal efficiency at full fire rate. As firing rate decreases, less gas is burned which reduces the amount of hot combustion gases generated at the burner. This in turn affects a number of combustion related factors including excess air ratio, combustion gas to heat exchanger surface ratio, the flow characteristics of the combustion gases, and vent dynamic pressure. The combination of effects caused by the reduction of firing rate on boiler performance greatly reduces the thermal efficiency of the two boilers. The last time the boilers were tuned, the boiler supervisor recalls their thermal efficiency being at 74 percent. Because of their now reduced load, the boiler supervisor estimates that the current efficiency of the boilers is no greater than 60 percent.

The boilers are greatly oversized for their current loads, which reduces their efficiency and increases their natural gas usage. No new loads will be supported by these boilers, which are slated to go offline in 5 years or less.

Solution

Purchase and install a new energy efficient boiler to take over the loads currently met by the boilers in Building 1277. Due to the large anticipated expense associated with removing the current boilers and installing a new unit in their place, as well as concerns about the presence of asbestos which may exacerbate this expense, it is recommended that HAAF either lease or purchase a portable boiler in the form of a mobile boiler room or mobile watertube boiler. The proposed boiler, in addition to being more energy efficient and using less natural gas, will be sized for the current steam load of the two remaining buildings, further reducing natural gas usage. A mobile solution also offers future flexibility if another boiler on HAAF or Fort Stewart, supporting a more critical system or systems, were to fail. The portable unit could quickly be put into operation while the failed system is repaired. HAAF personnel estimate that a boiler with a 20 hp fan rated at 2 MMBtu would be adequate to support the steam loads of the two buildings.

HAAF has used mobile boilers before and is satisfied with their performance and reliability. There is space for the portable unit immediately adjacent to Building 1277, and interconnections of water, steam and natural gas lines could be completed rapidly and easily. A mobile unit could be put into place quickly, the arrangements for which could probably be conducted using local funding from the base, not requiring higher headquarters appropriation and approval.

As the climatic conditions for HAAF and Fort Stewart are warm and dry, with warm summers and mild winters, the mobile boiler can be kept outside and not be affected by the elements. This is supported by the past use of a portable boiler at Fort Stewart, which was kept outside and fully exposed without affecting its performance.

Savings

The new boiler will match the load of the system and operate more efficiently. To ensure that the load will be adequately covered, a boiler with a rating of 4.2 MMBtu is used; a unit with a lower rating would cost less both in terms of first and operating costs.

Using conservative efficiency figures of 70 percent for both units, the current boilers consume approximately 28,600 MMBtu/yr while the proposed boiler will consume approximately 2,500 MMBtu/yr. At a cost of $5.88/MMBtu, the savings is $140,000 per year (Table 6).

Table 6. Estimated savings associated with boiler replacement in Building 1277.

Performance	Current Boilers	Proposed Boiler	Difference
Thermal Efficiency	70%	80%	10%
Burner Rating	Two 10 MMBtu Burners	One 4.2 MMBtu Burner	18 MMBtu
Annual Energy Use (MMBtu/yr)	28,600	3,125	25,500
Annual Energy Cost	$168,000	$18,000	$140,000
Annual Energy Cost Savings	—	—	$140,000

Annual energy use in this example is based on 1,000 equivalent full-load hours per year at an average price of $5.88/MMBtu. The electricity cost for operating the boilers and the associated fan systems is not considered.

Investments

The investment cost for this recommendation is the purchase or leasing of a mobile boiler, along with the purchase and installation price of natural gas, steam and water interconnections. A leading mobile boiler manufacturer states that purchasing a portable boiler will cost $162,000 or $66,000 per year ($5,500 per month) to lease.

The boiler supervisor at HAAF states that the interconnects for natural gas, steam and water could be purchased and installed for less than $5,000. The total installation cost, assuming a purchase scenario, is then $167,000. Assuming a contingency fee of 20 percent to cover unforeseen costs, the total installation cost is then $200,000.

Payback

Implementing BC#3 will result in a payback of 18 months.

CEP #8: Install Square D Controls Overheating on Cooling Tower, Replacing Siemens Controls (Building 1323)

Existing Conditions

At the time of the assessment, the two control sets on the cooling tower supporting the boiler in Building 1323 were overheating and burning out three to four times per year. Operators at the boiler plant report that once ordered, the controls take a considerable amount of time to become available, reducing the capability of the boiler to provide heat to HAAF tenants.

Solution

The controls on the cooling tower at the time of the assessment were manufactured by Siemens. Based on past experience, the boiler supervisor at Building 1323 believes that Square D controls would not burn out as frequently as the current Siemens controls. It is recommended, based on the supervisor’s experience and familiarity, that the Siemens controls be replaced with Square D controls to reduce the number of changeouts and to increase boiler operation and running time.

Savings

Savings will result form fewer changeouts of controls on the cooling tower. The boiler supervisor estimates that the two Siemens control sets burn out three to four times per year, with an associated cost of $600 per burnout, including labor costs. The Square D controls are approximately the same cost as their Siemens counterparts, and they can be installed for the same cost as well.

Assuming that the Siemens controls burn out three times a year, the savings will be the cost of the replacement controls. At $600 per control set, the savings will total approximately $1,800/year. There will also be savings associated with boiler operating more efficiently as the load on the systems remains high and constant, but those savings cannot be accurately calculated and are beyond the scope of this report.

Investments

The investment cost for this recommendation is the purchase and installation cost of the Square D controls. At $600 per control set, with no burnouts projected, the total cost is then $600.

Payback

Implementing BC#2 will result in a payback of less than 4 months.

CEP #9: HW Reset Based on Hourly Loads, Control Return Water and Supply Water Temperature (Operations Project, No Cost) (Building 1324)

Existing Conditions

Normally, boiler systems heat water to a pre-determined and steady high temperature without regard to outside conditions. During times of colder outside temperatures, discharge water temperatures must be sufficiently high so as to compensate for actual heat loss. However, the presetting of relatively high water temperature, while satisfying an extreme load on colder days, may waste energy on milder days.

This is true of the control settings of the boilers at Building 1323 on Hunter Army Air Field. The temperature controls that direct the water temperature of the boilers are not being manually adjusted often enough to maximize system efficiency.

Solution

There are different methods to controlling hot-water temperature at a desired level. One is to install a hot water reset system controller to control the boiler directly. The other is to install a controller to manage a mixing control valve on the hydronic loop, so the water temperature in the system can be reset through a mixing valve rather than at the boiler. Finally (and least expensively), the controls can be set manually on a daily, weekly, monthly or even seasonal basis, based on past and projected loads.

It is recommended that the boiler supervisor and operators of Building 1323 manually change the settings of the temperature controls at the beginning of the cooling season as well as at the beginning of the heating season.

The advantages of manually adjusting the controls are that doing so minimizes the layer of controls; it is an operations and maintenance action that requires no capital investment. With no controls, there is no point where, faced with the need to quickly handle a complaint, confused or frustrated technicians may simply disconnect a system to temporarily resolve the matter, resulting in greater ongoing energy use. Additionally, this is a simpler system that will work well without greatly adding to the workload of the operators or supervisor.

Benefits derived from this action include:

- increased boiler efficiency
- reduced heat loss through pipes
- elimination of boiler overheating
- shutting down of a boiler when it is not needed
- longer boiler life cycle due to reduced wear and tear.

Savings

Savings will occur due to less natural gas usage by the boiler in Building 1323. According to industry sources, the expected savings will range from 10 to 15 percent of the natural gas used by the boiler. To be conservative, a figure of 5 percent will be applied to the boilers' natural gas usage at HAAF.

With the boiler in Building 1323 rated at 18 MMBtu/hr, and using an estimated 1,000 heating hours per year for HAAF, the calculated natural gas usage and cost savings are:

18 MMBtu/hr x 1000 hr/yr x 0.05 = 900 MMBtu/yr

and

900 MMBtu/yr x $5.88/MMBtu = $5300/yr

Investments

Manually changing the boiler controls seasonally will take less than an hour twice a year. As the boiler operators and supervisor are already on site, these changes can be conducted as part of their regular job functions. As the amount of time this action takes is negligible, there is no associated investment cost.

Payback

Implementing BC#1 will result in immediate payback.

Notes

Fort Stewart and HAAF may want to consider automatic controls in the future. Automatic controls adjust for varying temperatures and will bring a degree of savings for every degree the outside temperature rises. A reset controller automatically measures the outside air and adjusts the hot water temperature accordingly. A cutout control turns off the heating system when the outside air reaches a preset temperature. Such control systems, depending on installation type, have paybacks that range from 1 to 3 years.

Post-Wide Electrical (Fort Stewart)

EL#1: Install Supplemental Timers at Select Site Locations (such as the Rock of Marne Memorial and potentially some of the parking lots) To Turn Off the Lights at Somewhere Between 10:00 PM and Midnight

Existing Conditions

Some areas on Post that become unused from late evening until morning have site lighting luminaires that stay on all night.

Solution

Install supplemental timers (to work in conjunction with the photo cells) that would turn off the unnecessary luminaires at somewhere between 10:00 PM and midnight.

Savings

Savings accrue from reduced electrical energy use for an average of 8 hours per day per luminaire. Roughly calculated savings, using the Rock of Marne Memorial as a basis, which has approximately 40, 50-watt (including ballast) low level luminaires, are:

(40 x 50 x 8 x 365)/1000 = 5840 kWh per year x $0.043/kWH
= $251 per year.

Investments

The estimated investment for EL#1, using the Rock of Marne Memorial example, amounts to $250 including the interface to the photo cell/branch circuits.

Payback

The estimated payback for EL#1 occurs in approximately 1 year.

EL#2: Install Power Factor Correction Capacitors To Eliminate Billing Penalties

Existing Conditions

When the power factor is below 95 percent lagging, the Post is charged 27¢/kVAR for all kVARs in excess of one third of the measured kW in the current month.

Solution

Install sufficient capacitors at the medium voltage (12.47 kV) distribution level to improve the power factor to 95 percent at worst case (highest) demand conditions. This would require approximately 4000 kVAR with automatic VAR control.

Savings

Savings accrue from eliminated excess kVAR charges ($0.27 per kVAR) from Georgia Power. Roughly calculated savings, based on previous billings, are $12,000 to $15,000 per year.

Investments

The estimated investment for EL#2 amounts to $200,000.

Payback

The estimated payback for EL#2 occurs in approximately 15 years.

HVAC (Fort Stewart)

Assessment results for facilities regarding HVAC, listed in Table 7, are documented by ECM.

Table 7. Evaluated facilities and ECMs for HV.

Facility	ECM	System Category
230 / 241 / 270 / 1160 / 1170 / 1201 / 1205 / 1208 / 1209 / 1211 / 1215 / 1216 / 1220 / 1245 / 1254 / 1257 / 1259 / 1261 / 1262 / 1263 / 1265 / 1320 / 1330 / 1340 / 1510 / 1512 / 1540 / 1620 / 1630 / 1720 / 1731 / 1809 / 1810 / 1820 / 1840 / 2910 / 4502 / 4528 / 4577 / 4578 / 8804 / 7783	Turn off AC units in office areas when not in use	HV
Post-Wide Maint Fac	Install building exhaust fans for increase circulation for comfort and to replace the individual vehicle exhaust hoses	HV
405	Remote thermostatic control of temperature of AHU (Automated Building Management System)	HV
405	Kitchen exhaust hood – Shut off airflow on hood over serving/storage area	HV
512	Provide some cooling in kitchen / Rebalance airflow and distribution system / Air-supply hoods / Heat recovery with desiccant system	HV
212/213/215/216/218/501/503/ 504/514/516/517/518/629/630/ 631/632/633/634/635/635/636/ 637/712/713/714/715/717/718 / 719/ 720/810	Barracks dehumidification	HV
1170	Install central cooling and eliminate all portable coolers and fans to increase productivity	HV
230	Repair central AC system and eliminate window units	HV

Facility	ECM	System Category
Post-Wide Maint Fac	Long Term unoccupied lockdown master shutoff of building systems (HVAC, Lighting, etc.)	HV
1170	Change location of radiant heaters to improve heating effectiveness	HV
1620	Insulate air system ductwork to stop condensate leakage	HV
620	Duct fresh outdoor air to diffuser installed in ceiling	HV
1160 / 1265 / 1340	Install new controls on Air Handling Units and commission	HV
Post-Wide Maint Fac	Central Monitoring System	HV

HV#1: Turn Off AC Units in Office Areas When Not in Use (Maintenance Facility Buildings 230, 241, 270, 1160, 1170, 1201, 1205, 1208, 1209, 1211, 1215, 1216, 1220, 1245, 1254, 1257, 1259, 1261, 1262, 1263, 1265, 1320, 1330, 1340, 1510, 1512, 1540, 1620, 1630, 1720, 1731, 1809, 1810, 1820, 1840, 2910, 4502, 4528, 4577, 4578, 8804, and 7783)

Existing Conditions

Office areas of the maintenance facilities are currently operated 24/7 regardless of occupancy schedules. Many were observed to be completely unoccupied due to deployment yet AC units continued to operate.

Solution

Install timed controls to turn the units off while unoccupied.

Savings

Savings would come from fan energy and heating and cooling savings:

- cooling:
  - outside air flow: 500 cu ft/minute (CFM)
  - average OA enthalpy: 34.4 Btu/lb
  - supply enthalpy: 23.0 Btu/lb
  - hours of unnecessary operation: 3000hrs/yr
  - cooling efficiency: 2kW/ton
  - electricity cost: $0.043/kWH
  - Annual savings = $552
- fan energy:
  - total fan size (supply and return) 5 Hp
  - hours of operation before: 8760 hr/yr

- hours of operation after: 2080
- motor efficiency 82%
- electricity cost: $0.043/kWH

Then the annual savings = $783

For a total savings of: $1,335

Investments

Simple timed on/off control would cost approximately $200 per unit.

Payback

On/off controls tend to become disabled after a period of time if not monitored so a cost of $100/year per unit to check operation and make necessary adjustments and repairs 3 times a year should be allowed.

Simple payback = 200/(1335 – 100) = 0.16 yrs.

HV#2: Install Building Exhaust Fans for Increased Circulation for Comfort and To Replace the Individual Vehicle Exhaust Hoses (Post-Wide Maintenance Facilities)

Existing Conditions

The maintenance facilities are use to repair various Army vehicles. Their design is basically a narrow building that allows these vehicles driven into the building from both sides. This results in a series of roll-up doors on each side of the building. Inside each work bay is an exhaust system that includes a hose to fit over the vehicle's exhaust pipe so that the exhaust gases created by running the vehicle's engine are collected and removed. Currently these exhaust system are seldom used due to the time required to fit the hose over the tail pipe. There is no other ventilation equipment provided in the maintenance areas. Heating is provided by unit heaters located in the upper strata of the building.

Since the exhaust equipment is not used exhaust fumes are present in the building when vehicles are running. The maintenance area is also quite hot during the summer months.

Solution

This project is to install a maintenance area ventilation system that will consist of exhaust fans placed in the upper side wall and wall mounted air intake louvers on the opposite wall. Using a ventilation rate of 10 air changes per hour or about 4 CFM/sq ft, a 30,000 CFM exhaust fan is chosen with gravity wall dampers for the opposite wall. For a maintenance having nine 35 ft wide bays with 18 roll-up doors for vehicle entry three exhaust fans will be required.

Savings

Factors: not running; productivity improvement of 1 %

30 persons X $50/ hr X 1300 hrs/ yr X 1% improvement = $19,500/yr

Additional fan HP:

Energy use = 3 fans X 5 hp X 0.746/ kWh/hp X 1300 hrs/yr = 14,547 kWh/yr

Energy cost = 14,547 kWh/yr X $0.0433/kWh = $630/yr

Total cost savings = $18,870/yr

Investment

The cost of the three exhaust fans placed in the building wall above the roll-up doors is $20,000. This cost includes the air intake louvers.

Payback

Payback = $20,000 / $18,870/yr = 1.06 yrs.

HV#3: Provide Some Cooling in Kitchen / Rebalance Air-flow and Distribution System / Air-Supply Hoods / Heat Recovery with Desiccant System (Building 512)

Existing Conditions

The kitchen area in this dining facility is not cooled in the summertime. Four 16 X 4.5 ft kitchen hoods run all the time. Most of the supply air enters the kitchen area between the middle two hoods. Several pedestal propeller fans also provide heat relief for the workers. The resulting air turbulence in the area causes the hoods to perform poorly and blows out the cooking equipment pilot lights.

Solution

Provide cooling to the space and recover energy from the exhaust air streams. Rebalance the supply air distribution to avoid the high air movement by the kitchen hoods. The cooler air will eliminate the need for the propeller fans which also affect the kitchen hood performance. After the installation of the new equipment, rebalance the supply air flow into the kitchen.

Evaluate the two outer kitchen hoods for contaminants in the air stream, and if none are present, install heat recovery units on these exhaust systems to reduce the cooling requirements of the new makeup air unit.

A desiccant system with heat recovery was considered, but deemed too expensive to install. The maintenance on the heat recovery device would be expensive because of the high probability of collecting cooking grease on the heat exchanger.

Savings

The temperature in the kitchen is about 10 °F above outside temperature and the kitchen area is very humid due to cooking operations. The efficiency of those who work in the kitchen could be improved by an estimated 10 percent with cooler temperatures. Since 10 cooks work in the kitchen, the improvement will save about 50 percent of the wages of one cook.

12 hrs/ day X 180 days/yr X $50/hr X 50% = $54,000/yr

Four propeller fans will not be required.

4 X 0.5 hp X 0.746 kW/hp X 180 days/yr X 12 hrs/day = 3,222 kWh/yr

Heat Recovery Winter Savings:

Two hoods exhaust approximately 15,000 CFM.

1.08 X 15,000 CFM X 10 F X 12 hrs/ day X 150 days/yr = 291 MM Btu/yr

Cooling Savings = 1.08 X 15,000 CFM X 5 F X 150 days/yr X 8hrs/day / 12000

Btu/ton = 8100 ton hrs/yr

kWh/yr savings = 8100 ton hrs/yr X 15,000 Btu/ton hr = 121 MM Btu/yr

Fuel energy savings = 291 MM Btu / (0.9 X 0.74) = 437 MM Btu/yr

Heating Energy Cost Savings = 437 MM Btu/yr X 2.59/MM Btu = $1106/ yr

Cooling Energy Use:

Cooling tons = 15,000 CFM/200 CFM/ton = 75 tons

Energy use = 75 tons X 1.2 kW/ton X 1500 full load hrs/yr = 135,000 kWh/yr

Additional electrical cost = 135,000 kWh X $0.043 = $5,805/yr additional cost

Total savings = $49,301/yr

Investment

Cost of new HVAC unit = 15,000 CFM X $5/CFM = $ 75,000

Installation $100,000

Rebalance of the air flow in the kitchen = $10,000

Total cost = $185,000

Payback

$185,000/$49,300/yr = 3.75 yrs

HV#4: Remote Thermostatic Control of Temperature of AHU (Automated Building Management System) (Building 405)

Existing Conditions

Many rooms in the Community Club are kept at 65 °F or (or cooler) even though the rooms are not in use. This excessive cooling wastes energy and can also cause cooling coils to freeze and become blocked with ice, which takes the air conditioning unit out of service for a day.

There are 175 tons of cooling provided by 15 roof top air handling units.

Solution

Install a central control system that will control space temperatures remotely. This controller should be placed in the Community Club's manager's office so he can control the room space temperatures.

Savings

Approximately half the space in the building receives partial use, requiring an estimated 80 tons of cooling to service these spaces:

Excessive cooling = 80 tons x 0.8 kW/ton x 1500 full load hrs/ yr x 50% of the time = 48,000 kWh/yr

Maintenance hrs = 8 units x 4 calls/ yr x 3 hrs/ call = 96 hrs/ yr

Investment

It is estimated the control system would cost $15,000 to install.

Payback

Payback = $ 15,000/ (48,000 kWh x $0.043/kWh + 96 hrs x $60/hr) = $15,000/ $7824 = 1.5 yrs.

HV#5: Kitchen Exhaust Hood – Shut Off Airflow on Hood over Serving/Storage Area (Building 405)

Existing Conditions

The kitchen hood located over cooking equipment has a similar hood also installed over serving equipment in an adjacent room that shares a common wall. The serving equipment is no longer used, but air continues to be exhausted from the hood. Consequently, air-conditioned air is exhausted outside through the disused hood.

Solution

The exhaust hood in the old serving area is 35 ft long and 4 ft wide on each side. The exhaust openings in the hood could be covered by stainless steel sheet metal. The exhaust fan could then be slowed down to a speed that exhausts the correct amount of air for the kitchen side of the hood. The supply air units that serve this area will also need to be properly adjusted to maintain the air balance between the kitchen and adjoining spaces.

Savings

Hood area = 35 x 4 ft = 140 sq ft

With an exhaust air flow of 50 fpm the exhaust air flow = 7,000 CFM.

The fan motor HP for the supply and exhaust air stream is approximately 5 hp each for a total of 10 HP which operates an estimated 14 hrs/day 365 days per year. The cooling tonnage is estimated to be 35 tons which is 200 CFM per ton. There are approximately 1500 full load cooling hours per year.

Fan motor kWh = 10 hp x 0.746 kW/hp x 14 hrs/day x 365 days/yr = 38,120 kWh/yr

Cooling energy savings:

35 tons x 0.8 kW/ton x 1500 full load hours/yr = 42,000 kWh/yr

Heating energy savings:

Average winter temperature is 55 °F, therefore there is a 10 ° rise by the supply air in the winter.

1.08 x 7000 CFM x 10 °F x 5 month x 30 days x 14 hrs/day = 158.7 MMBtu/yr

Natural gas input = 158.7 Btu/0.8 furnace efficiency = 198 MMBtu/yr

Cost savings = 198 MMBtu/yr x $5.68 = $1250

(38120 + 42000) kWh/yr x $0.043 / kWh/yr = $3,445/yr

Investment

To blank off the exhaust air openings and rebalance the supply air and the exhaust units it is estimated to cost $ 12,000.

Payback

Payback = Cost/ annual savings = $12,000/ $4695 = 2.56 years

HV#6: Barracks Dehumidification

Existing Conditions

The barracks consist of 31 buildings, designed as modules. There are (18) 3-module, (12) 4-module and (1) 5-module barracks, each with its own day room and Laundromat on the first level. There are 68 sleeping rooms in the 3-module, 92 in the 4-module, and 116 in the 5-module.

Each group of 2 bedrooms is heated and cooled by an individual fan-coil unit in the ceiling space, with outside air supplied to the intake of the fan coil unit by a separate, dedicated makeup air unit on the roof, or in the attic space on barracks that have been re-roofed. The outside air enters the space above the ceiling, and the flow is influenced by the condition of the filters in the return air grille, many of which are too close to the evaporator coil in the room fan-coil units.

The air is not being properly dehumidified by the room fan-coil units, leading to excessive temperature turndown of the thermostats by the troops in an effort to feel comfortable. Thermostat settings in occupied barracks are as low as 60 °F. In unoccupied barracks, the temperature settings on the wall thermostats vary from 65 to 80 °F, and the fan settings from “auto (fan cycling)” to “constant high speed.”

Findings

Filters in most rooms are too close to the cooling coil in the fan-coil units, not allowing return air from the room to properly flow across the cooling coil. This decreases the effectiveness of the coil, which reduces its capability to reduce temperature and humidity.

Approximately 2400 gal of fresh water has to be added every day to the chilled water system because of leaks in the piping. This is an increase of 33 percent from less than a year ago. This causes sludge to form in pipes, clogging strainers and reducing water flow to cooling coils. This sludge reduces the heat transfer and thus the cooling capacity of the coil. The maintenance on the units is also intensified because of the need to clean the strainers on an almost continuous basis.

The water temperature entering the chilled water coils in the barracks buildings is approximately 50 °F, even though the water temperature leaving the central energy plant (CEP) is now at the original design temperature of 42 °F with the use of rental chillers. 50 °F water is not conducive to good dehumidification.

The insulation around the pipes and control valves on the room fan-coil units allows condensation to leak onto the ceiling tiles in many rooms, leading to mold growth.

Water problems and mold growth increase the maintenance required in the barracks relative to replacing ceiling tiles and repairing insulation, as well as repainting, replacing carpeting, etc.

Air infiltration into some of the rooms from the outside causes excessive humidity and mold problems.

The makeup air units on the roof or in the attic spaces are difficult to maintain, and have the same problems with the chilled water coils as the fan-coil units mentioned above. As a result, the makeup air to the fan-coil units is not cooled and dehumidified by these units, as many of them are not operating. This increases the load on the fan-coil units, causing them to run longer, thereby using more energy.

Portable space dehumidifiers have been added to the rooms to attempt to reduce the humidity in the rooms. These not only add to the electrical load but also add additional heat to the rooms due to the heat of compression of the compressors. Because they shut off when the drain pans are full, they must be emptied almost daily by the room occupants. This does not happen much of the time, thus defeating the purpose of the dehumidifiers.

Drain lines get plugged, causing water backups in lower rooms. The drain lines are difficult to clean out due to their location in the buildings.

Solutions

The return air filters located in the ceilings should be moved to another ceiling tile that is next to the one they're now in so the air from the room as well as the makeup air properly flows through the cooling coil in the fan-coil unit.

Provide occupancy sensors to turn off lights when rooms are unoccupied (this is covered in another ECM).

Set thermostats in unoccupied barracks to "automatic" fan and to 78 °F. This will eliminate unnecessary operation of room fan-coil units.

Repair or replace the insulation on the piping to the room fan-coil units to eliminate dripping from pipes and valves.

Make sure that the drain pans in the fan-coil units catch all condensation and cleaned them regularly to eliminate condensate backups and overflow.

Perform pressurization air tests on individual rooms to determine where outside air is infiltrating, and repair those areas.

Install outside, on the ground, new dedicated Makeup Air (MUA) Units with heat recovery sections for each barracks rather than using the existing small fan-coil units that are on the roof or in the attics. Decouple these new units from the CEP by using packaged units with direct expansion coils and integral compressors to ensure proper moisture removal from the outside air. The heat recovery section will add free reheat to the cooled air as well as providing pre-cooling to the outside air, and the units will be easier to maintain than the existing rooftop and/or attic units, which are difficult to get to.

Design the air flow of the new MUA units for 30 percent greater volume than is being used now, and change the distribution of the air so it flows directly into the individual rooms rather than into the fan-coil units. For example, 3-barracks units are currently designed for a total of 3400 CFM of outside air (50 CFM per room). This would be increased to 4420 CFM (65 CFM per room). This will provide drier, dehumidified air directly into the rooms to be more healthful and comfortable for the troops, as well as further pressurize the rooms to minimize infiltration, as the bathroom exhaust fans are sized for 36.7 CFM. It will also not use any additional effective horsepower to move the air, as the larger supply air fans are more efficient than the smaller ones used in the individual fan-coil MUA units. The same percentage increase in air would be provided for the four- and five-barrack modules.

Savings

Cleanup costs for barracks are more than $1,000,000/year. Mold cleanup makes up more than 50 percent of this total. Savings are conservatively estimated at $500,000.

The rooms should require decreased cleanup and painting. At 10 percent of the rooms/year, this equals:

246 rooms at $300 = $73,800.

The need for dehumidifiers will be eliminated. Assuming 20% of the dehumidifiers/year are replaced at a cost of $150 ea:

20% x 2460 rooms x $150 = $73,800.

The operating cost of the dehumidifiers, which will be eliminated, is:

180 days/yr at 5 amps = 2484 kWh/yr x $0.043/kWh x 25% operating time x 2460 rooms = $65,700.

The actual kW savings = 2484 kWh/yr x 25% operating time x 2460 rooms = 1,527,660 kWh.

Additional reheat will not be required, as the new MUA units provide “free” reheat through the energy recovery recuperators. The reheat savings at the barracks will be 370MMBtu/hr / bldg / yr = 11470 MMBtu/hr. The actual savings of fuel input at the boilers, assuming a conservative 10 percent of energy lost in distribution and 76 percent boiler efficiency = 16769.01 MMBtu/hr/yr.

The energy cost savings is 16769.01MMBtu/hr x $2.59/MMBtu/hr = $43,400

The additional energy cost of the new MUA units is 19,605 kWh/bldg/yr x 31 x $0.043 = ($26,300.)

The additional electrical energy is 19,605 x 31 = (607,755kWh)

Annual Cost Savings = $730,400.

Annual Energy Savings:

Fuel = 16769.01 MMBtu/hr/yr.

Electrical = 919,905 kWh/yr.

Investment

31 MUA Units at an average cost of $60,000 = $1,860,000

Installation of MUA Units, including concrete pad, fence, piping, wiring, etc. = $575,000

Ductwork, insulated, including balancing dampers, etc. = $210,000

Supply air grilles and new ductwork in each room = $200,000

Startup, commissioning, owner training = $35,000

Engineering, drawings, construction oversight, etc. = $230,400

Note: The assumption has been made, based on conversations with base personnel, that electrical capacity is available at each barracks for the additional load of the MUA units.

Total Cost: $3,110,400

Since each of the barracks is an individual unit, the project could be done in phases.

A phased schedule could cost up to 15 percent additional, depending on the scheduling.

Payback

Payback = Cost / annual savings = $3,110,000 / $730,400 = 4.3 years

HV#7: Install Central Cooling and Eliminate All Portable Coolers and Fans To Increase Productivity (Building 1170)

Existing Conditions

During hot weather conditions, the temperature inside the maintenance facilities will exceed the outside temperature by a few degrees and it can exceed 100 °F on the warmest days. The people working inside these buildings use large fans to blow air across their bodies and a few units have an evaporative cooler to depress the temperature approximately

10 °F. When the temperature becomes quite hot the productivity of the workers suffers and more rest breaks are needed.

Solution

To reduce the summertime temperatures a central air conditioning system can be installed. Using Building 1170 as an example, there are 14 double maintenance bays each 80 ft long by 35 ft wide. This equals 39,200 sq ft of floor area. For cooling in this area a value of 200 sq ft per ton would be appropriate. The total cooling tonnage is equal to 196 tons.

Savings

Productivity would increase by an estimated 5% during the 6 months of cooling.
Cost savings = 25 persons X 24 weeks/ yr X 50 hrs/ week X 5% X $50/ hr = $75,000/yr

Energy use = 196 tons X 1.2 kWh/ton X 800 Eq. full load hrs = 188,160 kWh/yr

Additional Energy Cost = 188,160 kWh/yr X $0.0433 = $8,147/yr

Fan motor savings = 20 fans X 0.5 hp X 0.746 kW/hp X 1200 hrs/ yr = 8,952 kWh/yr

Fan motor cost savings = 8,952 kWh/yr X $0.0433 = $388/yr

Total cost savings = $75,000 - $8,147 + $ 388 = $67,241/yr

Investment

The new air conditioning system will cost approximately $2,000/ ton or $392,000

Payback

Payback = $392,000/ $67,241/yr = 5.8 years.

HV#8: Repair Central AC System and Eliminate Window Units

Existing Conditions

The office areas are currently cooled via approximately four window air conditioning units. A central air conditioning system exists but needs repairs.

Solution

Replace central AC unit with one having a Seasonal Energy Efficiency Rating (SEER having units of BTUH/Watt) of at least 14.5. Remove window AC units.

Savings

Replacing window units with a SEER of 6 with a central unit having a SEER of 13 would result in a 54 percent savings. This assumes the same cooling is provided:

SEER = Cooling Provided/Power In

Power In After = Power In Before * (SEER1/SEER2)
= Power In Before * (6/14.5)
= 0.41 Power In Before; or a 59% savings

It is estimated that the units run an average of 4 hours a day (50 percent duty cycle) 5 days per week for 24 weeks a year or 480 hours a year. The existing units are approximately 16,000 BTU/hr units. Assuming a SEER of 6 the existing units require 2666 Watt of power input.

Savings = 2.666kW/Unit * 480 hr/yr * 5 Units * $0.043/kWH * 0.59 = $162/yr

Investments

Removal of non-functional system and window units = $100

Installed cost of new 5 Ton central system = $3000

Payback

Due to the low payback it is recommended that this ECM be performed when the existing window AC units fail.

HV#9: Long Term Unoccupied Lockdown Master Shutoff of Building Systems (HVAC, Lighting, etc.) (Post-Wide)

Existing Conditions

Soldiers stationed at Fort Stewart are frequently deployed for extended periods of time. In some instances they are gone for up to a year or longer. During these times, many of the vehicle maintenance facilities are not utilized. When this happens it appears that the troops leave in a hurry and many of the energy using systems are not placed in a shutdown mode.

Lights were found on; ventilation equipment was still operating and process equipment such as air compressors were running.

The experience gained from visiting one of the maintenance facilities will be used to evaluate this ECM.

Solution

Install a master shutoff switch that will allow only those devices required to operate still functioning. Electrical power to the rest of the equipment will be terminated. This will require the placing of switches on the power feeds to this equipment.

Savings

Based on our field observations approximately 5 kW of lighting was left on it one of the shutdown maintenance facilities. Also, three fans approximately 1/3 hp each were running and a 10 hp air compressor that operated about 10 percent of the time.

Electrical use = (5 kW + 0.746 kW/hp X 2 hp) 2 months/ yr X 30 days/ month X 24 hrs/ day = 6,470 kWh/yr

Energy cost savings = 6,470 kWh/yr X $0.0433/kWh = $280/yr

Investment

The cost to install a master shutoff switch depends on the electrical circuits in the building. The required systems during a shutdown are emergency lights and some minimal heating system. It is estimated that those systems could be isolated from the incoming electrical service and a master shutoff switch be installed for approximately $10,000.

Payback

Payback = Cost/ annual savings = $10,000/ $280 = 35 years

HV#10: Change Location of Radiant Heaters To Improve Heating Effectiveness (Post-Wide)

Existing Conditions

The radiant heaters are installed along the side of the building. These units are installed over the roll-up door that opens to the outside in each bay. They are also over the crane rail that runs the length of the building. When the radiant system is operating it heats building components that are in the upper elevation of the building and elements of the outer wall which transfers the heat to the outside. As the result the amount of heat that reaches the working level of the building is greatly reduced and the maintenance spaces are cold in the winter.

Solution

Rotate the end of the radiant heater that is not connected to the exhaust flue 90 degrees so it reaches toward the middle of the building. At this location the radiant heater will be over the general repair area and will more effectively heat the occupied area of the building. The radiant heaters are approximately 25 ft long and a maintenance bay is 40 ft long.

Savings

The radiant heaters are estimated to have a heating capacity of 60,000 Btu/hr and thus would use approximately 75 cu ft of natural gas at high fire (using 1000 Btu/ CF of natural gas). These heaters are used an estimated 12 weeks per year or 600 hours. Relocating the heaters will improve the heating performance by 30 percent and will reduce heating energy use by 10 percent.

Energy savings = 10% X 75 CF of gas/hr X 600 hrs/yr = 4,500 CF of natural gas/yr

There are approximately 28 bays with radiant heaters so annual energy savings = 4,500 cu ft of natural gas/yr X 28 bays = 126,000 CF/yr

The energy cost savings = 126,000 CF/yr X 1000 Btu/CF / 1,000,000 Btu X $5.68 /1,000,000 Btu = $715/yr.

Investment

Cost to rotate heaters = $ 1,000 / heater or $28,000

Payback

Payback = $28,000/$715/yr = 39 years

HV#11: Insulate Air System Ductwork To Stop Condensate Leakage (Building 1620)

Existing Conditions

Serving the office areas of this building are small air conditioning units. In some of these areas there was a presence of mold and water stained ceiling tiles cause by water condensing on cold elements old the air conditioning units.

Solution

To avoid condensation the cold surfaces must be isolated from the air in these spaces through the use of insulation and moisture barriers. This project will replace all the insulation on the supply air ducts, cold refrigerant lines and the air conditioning unit where condensate could occur.

Savings

The savings will be in reduced mold clean-up and ceiling tile replacement. There will also be a lower health care cost with the elimination of the mold in the work spaces.

Investment

The estimated cost of the insulation for the office areas in this building is $5,000.

Payback

The payback should be less than 1 year.

HV#12: Duct Fresh Outdoor Air to Diffuser Installed in Ceiling (Building 620)

Existing Conditions

This building is a converted barracks building that is currently used for administrative purposes. Outside air is ducted into each room and discharged above the drop ceiling. Also above this ceiling is a fan coil air conditioning unit. The fan coil unit draws air from the ceiling space and cools it, discharging the air back into the room. Air from the room is drawn through a filtered return air opening in the ceiling.

For improved air quality the outdoor air duct should either be connected to the air intake of the fan coil unit or the air should be delivered into the room. Connecting it to the fan coil unit would assure a portion of the air being discharged into the room is outside air. There is a potential problem with a direct connection in that, if the return air filter became plugged, then the fan coil would attempt to draw more than its share of outside air thus taking outside air from other rooms.

Solution

Provide a flexible duct connection to the outside air duct discharge in the ceiling space. Attach the other end of this flexible duct to a small grill that will be mounted in a ceiling tile. The outside air will then directly discharge into the room.

Savings

Better indoor air quality will reduce illnesses experienced by the occupants.

Investment

The estimated cost to place the flex duct and grille in each room is:

200 rooms x an estimated $100 per grill = $20,000.

Payback

Savings due to better air quality are difficult to quantify, but the payback should be less than 3 years.

HV#13: Install New Controls on Air Handling Units and Commission (Buildings 1160, 1265, and 1340)

Existing Conditions

Building environmental controls are currently standalone. The majority of controls observed in the maintenance facilities were inoperative and the HVAC equipment runs 24/7 in full cooling mode. Many actuators have been disabled, as have time clocks. The controls are pneumatic, which are maintenance intensive. This wastes fan electrical and cooling coil chilled water energy.

Solution

Install new direct digital controls, replace actuators, and connect so a monitoring system either in the same building where the AHUs are located or connect to a base wide monitoring system. Require the design to follow UFGS 13801 and 15951.

Savings

Savings would be specific to each building and air handler unit. See “Central Monitoring System” ECM (HV#20) for example savings.

Investments

The costs would also be specific to each air handler unit. These are relatively small units (supply fans of approximately 2 to 3 Hp) with relatively simple components. An installed cost of local controls, replacement of actuators and linkages would be approximately $3,000 per unit.

Payback

As with savings and investment, payback would be specific to each air handler unit.

HV#20: Central Monitoring System

Existing Conditions

Control of all systems is currently standalone. This makes monitoring and control of building environments extremely difficult. Any energy conservation strategies such as scheduled on/off, night setback, economizer, etc. are unlikely to function properly for a significant period of time without a central monitoring system. A central monitoring system would also allow the installation to implement central energy conservation measures such as demand limiting.

Solution

Install a central monitoring system with the capability to perform monitoring of building level systems as well as central energy management functions such as demand limiting. As building controls are retrofitted or new construction is performed with Direct Digital Controls (DDC) they could be connected to the post wide monitoring system through the installation communication backbone.

Savings

Savings would be dependent upon the number, type, and size of systems having DDC based controls that could be connected. Presently there are no known DDC based controls that would be compatible with a new monitoring system, so any savings would be dependent upon the installation and commissioning of DDC controls. Some examples of potential savings:

Timed motor shut off with the following parameters:

Motor size: 10HP

Operating Hours Before: 8,760

Operating Hours After: 2,080

Motor Efficiency: 82%

Savings: $1566 (based on $0.043/kWH)

Night Setback of Space Temperature (Heating):

Percentage of setback hours: 50%

Setback: 10 °F

HDD: 1900

Building Heating Coefficient: 20 BTU/sq ft HDD

Building Area: 1500 sq ft

Savings: 35.3 MMBTU/yr

Energy Cost: $2.59/MMBTU

Heating Efficiency: 65%

Savings: $140/yr

Night Setback of Space Temperature (Cooling):

Percentage of setback hours: 50%

Setback: 8 °F

CDD: 22800

Cooling Coefficient: 20BTU/sq ft HDD

Savings: 28.2 MMBTU/yr

Energy Cost: $7.2 /MMBTU

Heating Efficiency: 65%

Savings: $312/yr

Investments

The cost often depends on the number of systems to be connected because the software license is based on the number of “points” to be monitored and controlled. A “point” in this context is usually considered to be real world hardware such as analog and binary inputs and outputs, for example, temperature sensors, actuators, freezestats, and start stop signals for fans. One example of the purchase price of such a system is:

- software: Wonderware Intouch development and runtime license for a 500 point system: $3500
- hardware:
  - personal computer: $1000
  - printer: $600

Costs of setting the system up (creating graphics, connecting to the network, developing energy management functions, etc.) would also depend on the type and number of systems to be interfaced to. This would likely be much more than the initial purchase price.

Payback

This depends on a number of factors:

- number of systems connected
- types of systems connected
- size of systems connected
- energy savings strategies used.

Lighting (Fort Stewart)

Assessment results for facilities regarding building envelope, listed in Table 8, are documented by ECM.

cupancy Sensors in Restrooms, Conference Rooms and Large Open Spaces of Public Buildings Post-wide (Building 405)

Existing Conditions

In many cases, the lighting in restrooms, conference rooms, and large open spaces of public buildings are on 24 hours per day.

Solution

Install occupancy sensors in restrooms, conference rooms and large open spaces to turn off the lighting when the rooms are unoccupied, which could be as much as 50 percent of the time.

Table 8. Evaluated facilities and ECMs for LI.

Facility	ECM	System Category
405	Occupancy sensors in rooms (post-wide)	LI
100/230/241/ 270/1160/1170/ 1201/1205/1208/1209/1211/1215/1 216/1220/1245/1254/1257/1259/12 61/1262/1263/1265/1320/1330/134 0/1510/1512/1540/1620/1630/1720 /1731/1809/1810/1820/1840/2910/ 4502/4528/4577/4578/7704/7783/1 320-Carport	Install internal and external lighting controls on maintenance facilities and maintenance platforms	LI
Post-Wide Electrical	Add or replace photo cells for site lighting to turn off all luminaires during daylight hours (Cost and Savings)	LI
1620 / 1630	Install skylights/transparent panels	LI
270 / 1620 / 1630	Paint ceiling white to improve lighting conditions	LI

LI#1: Install OcSavings

Savings accrue from reduced electrical energy use for an average of 12 hours per day. Roughly calculated savings, using building 405 – Community Club, as a typical example, assuming 50 percent of the lighting could be controlled with occupancy sensors and a total lighting load of 101,382 watts at 2 watts per sq ft, are:

(50,691 watts x 12 x 365)/1000 = 222,027 kWh per year x $0.043/kWH = $9,547 per year.

Investments

The estimated investment for LI#1 amounts to approximately $5,500 for the above typical building assuming approximately 25 controlled rooms/spaces. In some rooms, such as small restrooms, it could be as simple as replacing the wall switch with an occupancy sensing switch. In larger rooms/spaces, one or more ceiling mounted occupancy sensors with relay interface to the branch circuit(s) will be required.

Payback

The estimated payback for LI#1 occurs in less than 1 year.

LI#2: Install Internal and External Lighting Controls on Maintenance Facilities and Maintenance Platforms

Existing Conditions

Interior lighting consists of 400 watt light fixtures usually two rows of four fixtures per maintenance bay. Most have several bay lights controlled by a single wall switch. Some are wired directly to a breaker panel. Nearly all facilities were seen to be operated with bay doors open, providing ample lighting, however lights were observed to be on. Several facilities have been unoccupied for several months yet all lights remain on. This indicates that lights are never turned off.

External lighting consists of various fixtures estimated to be between 200 and 400 watts. Some have photo sensors integral to the fixture, others do not. Many that have photo sensors are inoperative. The result is that approximately 50 percent of the external lights, which are needed only for night security, are on during the day.

Maintenance platforms have 150 watt lights arranged in 2 rows of 4 per bay. The platforms typically have four bays. The lights are controlled by one switch for each two rows. Interviews indicated they are rarely used at night. Approximately half were observed to be on during bright sunny days.

Solution

Install off-delay timers on interior lights of maintenance facilities and maintenance platforms. A mechanical type such as that commonly used on hot tubs, with a maximum on time of 12 hours is suggested. These can be put in place of the existing wall switches where they exist or near the breaker panel where lights are wired directly to them. Workers would turn the lights on when arriving for work and the lights would automatically turn off at the end of the time interval selected.

Install timed on-off switches on exterior lights. While photo sensors that work would minimize unnecessary lighting loads, the cost maintaining one sensor per light is prohibitive. Instead timed switches set to let the lights be on for the longest dark period of the year should be installed. This will not be optimal since daylight hours change, but will still save a significant amount. For those lights having photo sensors that work no change should be seen. The timers should be wired to control the maximum number of lights possible to minimize cost.

Savings

Savings calculations are based on the following assumptions:

- 38 maintenance buildings
- 7 maintenance platforms
- Installation of 205 interior lighting switches; installed cost of $150/switch; Design cost of $4725
- Interior lighting load of 661,200 Watts
- 6 hours/day 5 days/week
- Installation of 126 exterior switches
- 105,600 Watts maintenance port lighting load
- 15 maintenance port light switches
- 2 out of 7 maintenance ports lights on 3 days per week unnecessarily
- $44,353/year savings interior lighting
- $24,404/year savings exterior lighting
- $4857/year savings maintenance port lighting.

Investment

The total investment for LI#2 amounts to $65,300.

Payback

The payback for LI#2 occurs in:
$65,300 / ($44,353+$24,404+$4,857), or 0.89 years.

LI#3: Add or Replace Photo Cells on Site Lighting To Turn Off All Luminaires During Daylight Hours (Post-Wide)

Existing Conditions

In general, site lighting is high efficiency sodium or metal halide and most (if not all) have individual photo cells for on-off control. A number (approximately 10 percent) of the luminaires are on during daylight hours. This is a probable indication that the photo cells are not working properly.

Solution

Add or replace the failed photo cells to turn off all luminaires during daylight hours.

Savings

Savings accrue from reduced electrical energy use for an average of 13 hours per day per luminaire. Roughly calculated savings, based on 100 luminaires (10 percent of an estimated 1000 on the Post) at 275 watts (including ballast) per luminaire for 13 hours per day and $0.043 per kWh, are $5,611 per year. Where the luminaire wattage is higher (say 400 watts), the savings will obviously be more. Also, by casual observation, it appears in some areas that the roadway lighting may have a higher illumination level than is necessary. This should be checked, and if so, some of the luminaires could be disconnected or removed, which would add to the potential savings in electricity.

Investments

The estimated investment for LI#3 amounts to $57 per luminaire or $5,700 for 100 luminaires. It is assumed that the replacements will occur in mass rather than singly.

Payback

The estimated payback for LI#3 occurs in approximately 1 year.

LI#4: Install Skylights/Transparent Panels (Buildings 270, 1620, 1630)

Existing Conditions

This maintenance facility has very poor lighting which is made worst by a ceiling painted blue. When all the doors are closed supplemental/task lighting is required.

Solution

More natural light could be brought into the building through the use of skylights or transparent panels placed on the sidewalls above the doors.

Savings

The lights in each bay have a 400 watt bulb that can be turned off approximately 6 hours per day due to the use of natural light for savings of:

Energy savings = 400 w X 6 hrs/ day X 250 days/yr = 600kWh/yr

Cost savings = 600kWh/yr X $0.0433/kWh = $25.98 /yr

Investment

A bay is 35 ft wide and a transparent panel should be at least 3 ft high. The resulting area is 105 sq ft. The approximate cost of a transparent panel is:

$5 / sq ft x 105 sq ft = $525/ bay

Payback

$525/ ($ 26/yr) = 20 yrs.

LI#5: Paint Ceiling White To Improve Lighting Conditions (Buildings 270, 1620, 1630)

Existing Conditions

The color of the interior ceiling is dark. This results in decreased lighting level requiring lights to be on which also create more heat. It also increases the radiant heat felt by workers.

Solution

Paint the ceilings with a light colored (white) and low emissivity paint.

Savings

These building have a total lighting load of 36,000 watts. Assuming the lighter ceilings result in an average of 4 hours per day 5 days per week during which the lights can be shut off:

Savings = 4 hr/day * 5 day/week * 52 week/yr * 36kW * $0.043/kWH = $1610/yr

Investments

Estimated costs are:

$2.40/sq ft * 43,974 sq ft = $105, 376[*]

Payback

Due to the low payback, it is recommended that this ECM be performed when ceilings require new paint.

[*] The cost per square foot was estimated to be 150 percent that of setting up ladders, washing, sanding, and painting sheetrock ceiling, taken from RS Means "Facilities Maintenance & Repair Cost Data 2005," page I-145. A 50 percent premium was used because of the height of the ceilings.

Motors (Fort Stewart)

MO#1: Replace Standard Efficiency Motors with Premium Efficiency Motors in Various Buildings

Existing Conditions

A typical maintenance facility at Fort Stewart is powered by a variety of AC motors ranging in size from 1/2 hp to 25 hp. The majority of the motors are used to drive HVAC fans, boiler pumps, and air compressors. Four typical motor sizes found in the maintenance facility are 25, 3, 2, and 1 horsepower, running constantly throughout the year. These motors are all standard efficiency units.

Solution

Replace standard efficiency motors with premium efficiency motors as standard efficiency motors fail. This will decrease the electrical energy operating cost of the motors.

Savings

Savings result from the difference in energy consumption of a standard motor vs. a premium efficiency motor. Calculations involving savings are:

$$\text{ES} = \text{Horsepower X Operating Hours X Estimated Load Factor X } 0.746 \text{ X } \left(1-\frac{\eta_S}{\eta_P}\right)$$

$$\text{ES} = 3 \text{ X } 8{,}760 \text{ X } 0.85 \text{ X } 0.746 \text{ X } \left(1-\frac{0.815}{0.897}\right) = 1{,}523 \text{ kWh}$$

$$\text{ECS} = \text{ES X Electrical Rate}$$

$$\text{ECS}=1{,}523 \text{ kWh}\times\$0.043=\$65$$

The savings typical motor sizes in the maintenance facility are shown below in Table 9.

Table 9. Typical motor sizes for maintenance facilities.

Motor Size	Existing Efficiency (%)	Proposed Efficiency (%)	Energy Saved (kWh/yr)	Energy Cost Savings ($/yr)	Total Cost Premium ($)	Simple Payback (yrs)
25	88.5%	93.8%	3,146	$169	$823	4.9
3	81.5%	89.7%	1,213	$65	$189	2.9
1	80.5%	87.2%	526	$37	$229	6.2
1	75.1%	85.5%	4,885	$29	$136	4.7
Total	—	—	*4,885*	*$271*	*$1,241*	*4.6*

Investments

The implementation cost for this recommendation is the cost difference between the standard motors and the premium efficiency motor replacements, called the cost premium. The estimated investment for MO#1 varies depending on the motor size.

Payback

The estimated payback for MO#1 varies depending on the motor size, but ranges from 2.9 to 6.2 years for the four sizes indicated above.

Notes

The savings are estimated for typical motor sizes found in the maintenance facilities. However other motors sizes found in the maintenance facilities can be expected to have similar savings.

The following buildings were surveyed and found to have motors that can be replaced with premium efficiency units: Buildings 230, 241, 270, 1160, 1170, 1245, 1265, 1340, 1630, 4502, and 4577.

Summary of All Energy Conservation Measures

Of the 42 ECMs identified in this work, 22 were quantified with preliminary investment requirements (costs), estimated savings, and payback periods. Table 10 summarizes these 42 ECMs.

Table 10. Investment, savings, and payback of ECMs.

ECM	Description	Investment ($K)	Savings ($K)	Simple Payback (yrs)
BE#1	Properly commission HVAC units / Window film / Install automated building control systems / LED exit lights / Occupancy sensors to reduce lighting load / Install zone lighting capability (Auditorium)	48.0	8.1	5.9
BE#2	Coating on supply A/C ducts for more reflection	0.1	0.02	6.7
BE#3	Spray foam insulation to underside of new roofs	850.0	40.3	21.1
BE#4	Spray foam insulation on ceiling for insulation from roof heat	60.0	1.8	33.3

ECM	Description	Investment ($K)	Savings ($K)	Simple Payback (yrs)
BE#5	Change color of extended brown roof vertical surface to a lighter color	Unknown (Only cost is additional cost for special paint)	0.01	< 5
BE#6	Cool roofs	Unknown (Only cost is additional cost for special paint)	0.04	< 5
BE#7	Paint large metallic doors a more reflective color	Unknown (Only cost is additional cost for special paint)	None	Immediate
BE#8	When rooms not in use, isolate space from outdoor air by blocking exhaust opening and shutting off supply air unit	N/A	N/A	N/A
CA#1	Reduce compressor output pressure	0.0	0.18	0.0
CA#2	Repair compressed air leaks	0.7	0.7	1.0
CA#3	Recover heat from compressors in buildings	3.0	0.49	6.1
CEP#1	Foundation and drainage for woodchip pile for CEP (No overhead cover)	349.4	176.3	2.0
CEP#2	Optimize heat exchanger use	158.0	55.7	2.8
CEP#3	Install on-site cogeneration using both backpressure and steam condensing turbines	2453.3	385.2	6.4
CEP#4	Install on-site cogeneration using backpressure turbine	574.8	67.9	8.5
CEP#5	Install on-site cogeneration using steam condensing turbine	2144.2	229.8	9.3
CEP#6	Reduce temperature levels in the district heating system	2200.0	179.0	12.3
CEP#7	Replace boilers with the one unit currently in storage	$200	140	1.5
CEP#8	Install Square D controls overheating on cooling tower, replacing Siemens controls	$0.6	1.8	0.3
CEP#9	HW reset based on hourly loads, control return water and supply water temp (operations project, no cost)	$0	5.3	Immediate
EL#1	Install timers on selective equipment	0.25	0.25	1.0

ECM	Description	Investment ($K)	Savings ($K)	Simple Payback (yrs)
EL#2	To eliminate excess reactive demand penalties, install sufficient capacitors at the medium voltage (12.47 kV) distribution level to improve the power factor to 95% at the worst case demand conditions. This would require approximately 4000 kVAR with automatic variable control.	200.0	13.5	14.8
HV#1	Turn off AC units in office areas when not in use	0.2	1.2	0.2
HV#2	Install building exhaust fans for increase circulation for comfort and to replace the individual vehicle exhaust hoses	20.0	18.9	1.1
HV#3	Remote thermostatic control of temperature of AHU (Automated Building Management System)	15.0	7.8	1.9
HV#4	Kitchen exhaust hood – Shut off airflow on hood over serving/storage area	12.0	4.7	2.6
HV#5	Provide some cooling in kitchen / Rebalance air-flow and distribution system / Air-supply hoods / Heat recovery with desiccant system	185.0	49.3	3.8
HV#6	Barracks dehumidification	3585.9	728.6	4.9
HV#7	Install central cooling and eliminate all portable coolers and fans to increase productivity	392.0	67.2	5.8
HV#8	Repair central AC system and eliminate window units	3.1	0.2	19.1
HV#9	Long Term unoccupied lockdown master shutoff of building systems (HVAC, Lighting, etc.)	10.0	0.3	35.7
HV#10	Change location of radiant heaters to improve heating effectiveness	28.0	0.7	39.2
HV#11	Insulate air system ductwork to stop condensate leakage	5.0	Unknown (Savings due to mold clean-up and ceiling tile replacement)	< 1
HV#12	Duct fresh outdoor air to diffuser installed in ceiling	20.0	Unknown	< 3
HV#13	Install new controls on Air Handling Units and commission	TBD	TBD	TBD
HV#14	Central Monitoring System	2.0	TBD	TBD

ECM	Description	Investment ($K)	Savings ($K)	Simple Payback (yrs)
LI#1	Occupancy sensors in rooms (post-wide)	5.5	9.5	0.6
LI#2	Install internal and external lighting controls on maintenance facilities and maintenance platforms	65.3	73.6	0.9
LI#3	Add or replace photo cells for site lighting to turn off all luminaires during daylight hours (Cost and Savings)	5.7	5.6	1.0
LI#4	Install skylights/transparent panels	0.53	0.03	20.2
LI#5	Paint ceiling white to improve lighting conditions	105.4	1.6	65.5
MO#1	Replace standard efficiency motors with premium efficiency motors as standard efficiency motors fail	1.2	0.3	4.6
TOTAL of the 22 quantified economically		10019.6	1891.4	5.3

5 Conclusions and Recommendations

Conclusions

The Energy and Process Optimization Assessment at Fort Stewart/Hunter Army Airfield conducted Level I and limited Level II analyses to determine the economic potential for significant energy and cost reduction opportunities. The study identified solutions to critical cost issues and estimated the economics for the top ideas. Forty-two Energy Conservation Measures (ECMs) were identified in the Level I study (summarized in Table 10). The 42 measures are identified with the following systems:

1. Building Envelope (BE)
2. Compressed Air (CA)
3. Central Energy Plant (CEP)
4. Electrical (EL)
5. HVAC (HV)
6. Lighting (LI)
7. Motors (MO).

Economical quantifications of 22 of the 42 ECMs (Table 11) show that, when implemented, the ECMs will allow FSG to reduce its annual operating costs by approximately 10 percent ($1.89M). The capital investment required to accomplish these savings is approximately $10.0M, indicating an average simple payback period of 5.3 years (64 months). Central energy plant-related measures contribute to 57 percent of savings, HVAC systems 42 percent, building envelope 0.5 percent, and other systems (compressed air, electrical, lighting, motors) 0.8 percent.

Table 11. Investment, savings, and payback of the 22 quantified ECMs.

ECM	Description	Investment ($K)	Savings ($K)	Simple Payback (yrs)
BE#1	Properly commission HVAC units / Window film / Install automated building control systems / LED exit lights / Occupancy sensors to reduce lighting load / Install zone lighting capability (Auditorium)	48.0	8.1	5.9
BE#2	Coating on supply A/C ducts for more reflection	0.1	0.02	6.7
CA#1	Reduce compressor output pressure	0.0	0.18	0.0
CA#2	Repair compressed air leaks	0.7	0.7	1.0
CA#3	Recover heat from compressors in buildings	3.0	0.49	6.1
CEP#1	Foundation and drainage for woodchip pile for CEP (No overhead cover)	349.4	176.3	2.0
CEP#2	Optimize heat exchanger use	158.0	55.7	2.8
CEP#3	Install on-site cogeneration using both backpressure and steam condensing turbines	2453.3	385.2	6.4
CEP#4	Install on-site cogeneration using backpressure turbine	574.8	67.9	8.5
CEP#5	Install on-site cogeneration using steam condensing turbine	2144.2	229.8	9.3
EL#1	Install timers on selective equipment	0.25	0.25	1.0
HV#1	Turn off AC units in office areas when not in use	0.2	1.2	0.2
HV#2	Install building exhaust fans for increase circulation for comfort and to replace the individual vehicle exhaust hoses	20.0	18.9	1.1
HV#3	Remote thermostatic control of temperature of AHU (Automated Building Management System)	15.0	7.8	1.9
HV#4	Kitchen exhaust hood – Shut off airflow on hood over serving/storage area	12.0	4.7	2.6
HV#5	Provide some cooling in kitchen / Rebalance air-flow and distribution system / Air-supply hoods / Heat recovery with desiccant system	185.0	49.3	3.8
HV#6	Barracks dehumidification	3585.9	728.6	4.9
HV#7	Install central cooling and eliminate all portable coolers and fans to increase productivity	392.0	67.2	5.8

ECM	Description	Investment ($K)	Savings ($K)	Simple Payback (yrs)
LI#1	Occupancy sensors in rooms (post-wide)	5.5	9.5	0.6
LI#2	Install internal and external lighting controls on maintenance facilities and maintenance platforms	65.3	73.6	0.9
LI#3	Add or replace photo cells for site lighting to turn off all luminaires during daylight hours (Cost and Savings)	5.7	5.6	1.0
MO#1	Replace standard efficiency motors with premium efficiency motors as standard efficiency motors fail	1.2	0.3	4.6
Total of the 22 economically quantified ECMs		10019.6	1891.4	5.3

Recommendations

The Level I and limited Level II analyses of multiple complex systems conducted during the EPOA are not intended to be (nor should they be) precise. The quantity and quality of the systems improvements identified suggests that significant potential exists. It is recommended that FSG accomplish these potential cost savings by pursuing an aggressive program of process optimization linked to their ongoing ESCO efforts. It is also recommended that FSG apply the identified low-cost/no-risk (so-called "slam dunk") process improvement ideas from this analysis, which typically can be implemented quickly. However, the greatest profit opportunities need to be developed further by a Level II effort, geared toward funds appropriation. This effort most often requires a combination of in-house and outside support.

It is recommended that FSG pursue Level II of this EPOA. Recommendations for the scope of the Level II study can be based on the Level I results presented in Table 10. A specific Level II scope will be jointly developed by the CERL and FSG teams through review and discussion of results documented in this Level I report. The Level II report will include an analysis that "guesses at nothing – measures everything." The results will be a set of demonstrated process and systems improvements based on hard numbers. CERL and expert consultants will provide guidance and further assistance in identifying a specific Level II scope of work, respective roles, and the most expeditious implementation path. This will begin with a formal review of this (Level I) report, combined with a planning session to organize the Level II program.

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Appendix: Life-Cycle Cost Analyses for ECIP Consideration

Barracks Dehumidification

NIST BLCC 5.3-05: ECIP Report

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

The LCC calculations are based on the FEMP discount rates and energy price escalation rates updated on April 1, 2005.

Location:	**Georgia**	**Discount Rate:**	**3%**
Project Title:	Barracks	Analyst:	Dave Underwood
Base Date:	January 1, 2007	Preparation Date:	Wed Aug 24 13:57:21 CDT 2005
BOD:	October 1, 2007	Economic Life:	20 years 0 months
File Name:	C:\Program Files\BLCC5\projects\Stewart_Barracks.xml		

1. Investment

Construction Cost	$3,320,253
SIOH	$265,620
Design Cost	$0
Total Cost	$3,585,873
Salvage Value of Existing Equipment	$0
Public Utility Company	$0
Total Investment	*$3,585,873*

2. Energy and Water Savings (+) or Cost (-)

Base Date Savings, unit costs, & discounted savings

Item	**Unit Cost**	**Usage Savings**	**Annual Savings**	**Discount Factor**	**Discounted Savings**
Electricity	$12.60206	3,138.8 MMBtu	$39,556	14.692	$581,146
Energy Subtotal		3,138.8 MMBtu	$39,556		$581,146
Water Subtotal		0.0 Mgal	$0		$0
Total			*$39,556*		*$581,146*

3. Non-Energy Savings (+) or Cost (-)

Item	Savings/Cost	Occurrence	Discount Factor	Discounted Savings/Cost
Annually Recurring	$689,065	Annual	20.000	$13,781,300
Non-Annually Recurring				
Non-Annually Recurring Subtotal	$0			$0
Total	$689,065			*$13,781,300*

4. First year savings	$728,621	
5. Simple Payback Period (in years)	4.92	(total investment/first-year savings)
6. Total Discounted Operational Savings	$14,362,446	
7. Savings to Investment Ratio (SIR)	4.01	(total discounted operational savings/total investment)
8. Adjusted Internal Rate of Return (AIRR)	10.40%	(1+d)*SIR^(1/n)-1; d=discount rate, n=years in study period

Add or Replace Lighting Controls to Industrial and Administrative Facilities

NIST BLCC 5.3-05: ECIP REPORT

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

The LCC calculations are based on the FEMP discount rates and energy price escalation rates updated on April 1, 2005.

Location:	Georgia	Discount Rate:	3%
Project Title:	Stewart_Lighting	Analyst:	Dave Underwood
Base Date:	August 1, 2007	Preparation Date:	Thu Aug 04 11:26:59 CDT 2005
BOD:	November 1, 2007	Economic Life:	15 years 0 months
File Name:	C:\Program Files\BLCC5\projects\Stewart_Light.xml		

1. Investment

Construction Cost	$61,990
SIOH	$4,111
Design Cost	$9,650
Total Cost	$75,751
Salvage Value of Existing Equipment	$0
Public Utility Company	$0
Total Investment	$75,751

2. Energy and Water Savings (+) or Cost (-)

Base Date Savings, unit costs, & discounted savings

Item	Unit Cost	Usage Savings	Annual Savings	Discount Factor	Discounted Savings
Electricity	$12.60206	5,880.3 MMBtu	$74,103	12.035	$891,861
Energy Subtotal		5,880.3 MMBtu	$74,103		$891,861
Water Subtotal		0.0 Mgal	$0		$0
Total			*$74,103*		*$891,861*

3. Non-Energy Savings (+) or Cost (-)

Item	Savings/Cost	Occurrence	Discount Factor	Discounted Savings/Cost
Non-Annually Recurring				
Non-Annually Recurring Subtotal	$0			$0
Total	*$0*			*$0*

4. First year savings	$74,103	
5. Simple Payback Period (in years)	1.02	(Total investment/first-year savings)
6. Total Discounted Operational Savings	$891,861	
7. Savings to Investment Ratio (SIR)	11.77	(Total discounted operational savings/total investment)
8. Adjusted Internal Rate of Return (AIRR)	21.41%	$(1+d)*SIR^{(1/n)-1}$; d=discount rate, n=years in study period

On-Site Cogeneration Using Backpressure and Steam Condensing Turbines

NIST BLCC 5.3-05: ECIP REPORT

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

The LCC calculations are based on the FEMP discount rates and energy price escalation rates updated on April 1, 2005.

Location:	**Georgia**	**Discount Rate:**	**3%**
Project Title:	Cogen_BPCond	Analyst:	Dave Underwood
Base Date:	August 1, 2007	Preparation Date:	Fri Aug 12 13:30:58 CDT 2005
BOD:	October 1, 2010	Economic Life:	20 years 0 months
File Name:	C:\Program Files\BLCC5\projects\Stewart_CogenBPCond.xml		

1. Investment

Construction Cost	$1,948,619
SIOH	$319,998
Design Cost	$184,703
Total Cost	$2,453,320
Salvage Value of Existing Equipment	$0
Public Utility Company	$0
Total Investment	$2,453,320

2. Energy and Water Savings (+) or Cost (-)

Base Date Savings, unit costs, & discounted savings

Item	**Unit Cost**	**Usage Savings**	**Annual Savings**	**Discount Factor**	**Discounted Savings**
Electricity	$12.60206	113,283.1 MMBtu	$1,427,600	12.463	$17,792,310
Energy Subtotal		113,283.1 MMBtu	$1,427,600		$17,792,310
Water Subtotal		0.0 Mgal	$0		$0
Total			$1,427,600		$17,792,310

3. Non-Energy Savings (+) or Cost (-)

Item	Savings/Cost	Occurrence	Discount Factor	Discounted Savings/Cost
Annually Recurring	-$1,042,403	Annual	17.000	-$17,720,851
Non-Annually Recurring				
Non-Annually Recurring Sub-total	$0			$0
Total	-$1,042,403			-$17,720,851

4. First year savings	$385,197	
5. Simple Payback Period (in years)	6.37	(total investment/first-year savings)
6. Total Discounted Operational Savings	$71,459	
7. Savings to Investment Ratio (SIR)	0.03	(total discounted operational savings/total investment)
8. Adjusted Internal Rate of Return (AIRR)	-13.69%	(1+d)*SIR^(1/n)-1; d=discount rate, n=years in study period

On-Site Cogeneration Using a Backpressure Turbine

NIST BLCC 5.3-05: ECIP Report

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

The LCC calculations are based on the FEMP discount rates and energy price escalation rates updated on April 1, 2005.

Location:	Georgia	Discount Rate:	3%
Project Title:	Cogen_BPTurbine	Analyst:	Dave Underwood
Base Date:	August 1, 2007	Preparation Date:	Fri Aug 12 13:39:11 CDT 2005
BOD:	October 1, 2010	Economic Life:	20 years 0 months
File Name:	C:\Program Files\BLCC5\projects\Stewart_CogenBPTurbine.xml		

1. Investment

Construction Cost	$456,527
SIOH	$74,970
Design Cost	$43,273
Total Cost	$574,770
Salvage Value of Existing Equipment	$0
Public Utility Company	$0
Total Investment	*$574,770*

2. Energy and Water Savings (+) or Cost (-)

Base Date Savings, unit costs, & discounted savings

Item	Unit Cost	Usage Savings	Annual Savings	Discount Factor	Discounted Savings
Electricity	$12.60206	13,307.3 MMBtu	$167,700	12.463	$2,090,060
Energy Subtotal		13,307.3 MMBtu	$167,700		$2,090,060
Water Subtotal		0.0 Mgal	$0		$0
Total			$167,700		$2,090,060

3. Non-Energy Savings (+) or Cost (-)

Item	Savings/Cost	Occurrence	Discount Factor	Discounted Savings/Cost
Annually Recurring	-$99,812	Annual	17.000	-$1,696,804
Non-Annually Recurring				
Non-Annually Recurring Subtotal	$0			$0
Total	-$99,812			-$1,696,804

4. First year savings	$67,888	
5. Simple Payback Period (in years)	8.47	(Total investment/first-year savings)
6. Total Discounted Operational Savings	$393,256	
7. Savings to Investment Ratio (SIR)	0.68	(total discounted operational savings/total investment)
8. Adjusted Internal Rate of Return (AIRR)	1.06%	$(1+d)*SIR^{(1/n)-1}$; d=discount rate, n=years in study period

On-Site Cogeneration Using a Steam Condensing Turbine

NIST BLCC 5.3-05: ECIP REPORT

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

The LCC calculations are based on the FEMP discount rates and energy price escalation rates updated on April 1, 2005.

Location:	Georgia	Discount Rate:	3%
Project Title:	Cogen_CondTurbine	Analyst:	Dave Underwood
Base Date:	August 1, 2007	Preparation Date:	Fri Aug 12 13:28:14 CDT 2005
BOD:	October 1, 2010	Economic Life:	20 years 0 months
File Name:	C:\Program Files\BLCC5\projects\Stewart_CogenCondTurbine.xml		

1. Investment

Construction Cost	$1,703,092
SIOH	$279,678
Design Cost	$161,431
Total Cost	$2,144,201
Salvage Value of Existing Equipment	$0
Public Utility Company	$0
Total Investment	$2,144,201

2. Energy and Water Savings (+) or Cost (-)

Base Date Savings, unit costs, & discounted savings

Item	Unit Cost	Usage Savings	Annual Savings	Discount Factor	Discounted Savings
Electricity	$12.60206	99,975.7 MMBtu	$1,259,900	12.463	$15,702,249
Energy Subtotal		99,975.7 MMBtu	$1,259,900		$15,702,249
Water Subtotal		0.0 Mgal	$0		$0
Total			$1,259,900		$15,702,249

3. Non-Energy Savings (+) or Cost (-)

Item	Savings/Cost	Occurrence	Discount Factor	Discounted Savings/Cost
Annually Recurring	-$1,030,127	Annual	17.000	-$17,512,159
Non-Annually Recurring				
Non-Annually Recurring Subtotal	$0			$0
Total	-$1,030,127			-$17,512,159

4. First year savings	$229,773	
5. Simple Payback Period (in years)	9.33	(Total investment/first-year savings)
6. Total Discounted Operational Savings	-$1,809,910	
7. Savings to Investment Ratio (SIR)	-0.84	(Total discounted operational savings/total investment)
8. Adjusted Internal Rate of Return (AIRR)		$(1+d)*SIR^{(1/n)-1}$; d=discount rate, n=years in study period

Seasonal Temperature Reduction of HTHW

Existing Conditions

The outlet temperature of the cascade heat exchangers equals the supply water temperature of the District Heating (DH) Systems. It amounts 380 °F throughout the whole year.

Considering the whole year, the main users of the DH System are:

- Hospitals
- DFACs
- Domestic hot water (DHW) in the barracks
- Space heating in the barracks.

While the supply water temperature (TSHW) amounts to 380 °F, the return water temperature (TRHW) amounts to 240 °F at least in winter and much higher temperatures in summer (about 290 °F). The pressure on the system amounts to 185 psig on the supply water side and to 180 psig on the return water side during summer.

The piping systems length amounts to around about 12 miles, spreading between diameters of 8 to 10 in. in the main distribution system and smaller diameters in the subsystem (connections of the buildings to the conversion system). The origin pipes are made by steel with a steel jacket pipe with insulation but without corrosion protection. Since most of the pipes fails after only 20 years, the pipes are replaced by new ones. Figure A1 shoes the composition of the new piping system.

The new piping system shown in Figure A1 can withstand high water temperatures and does not need a corrosion protection from the outside.

Since about 20,000 gal of water is lost with the current DH system, the water is not treated as it should be. Therefore numerous leakages accomplishing from inside are estimated.

The Johnson Controls ESCO proposal exposes specific costs for installing 1 ft of this piping system at about $800 per foot-diameter (fd.), distributed over all diameters.

In the field, numerous of pit-holes are distributed. Therein the pipes are exposed to rain etc., since the pit-holes are covered by grilles. In addition to the rain water accumulating in the pit-holes, ground water adds up inside the pit-holes. Thus, some pipes are completely beneath the water level. There should be pumps inside but some of them do not seem to function (Refer to Figure A2).

Since the ground water level is quite high, well drains do not work.

As mentioned above, four main users can be identified and grouped as:

1. space heating
2. domestic hot water
3. process.

Groups 2 and 3 are operating through the whole year while Group 1 is only required during the heating periods in winter.

The processes include cooking and dishwashing in the DFACs (requires 270 °F) and sterilization at the hospital (requires 300 °F). The required temperature for space heating and domestic hot water preparation is less. They depend on the outdoor temperature as will as on the daily peaks for domestic hot water use (e.g., taking showers, etc.).

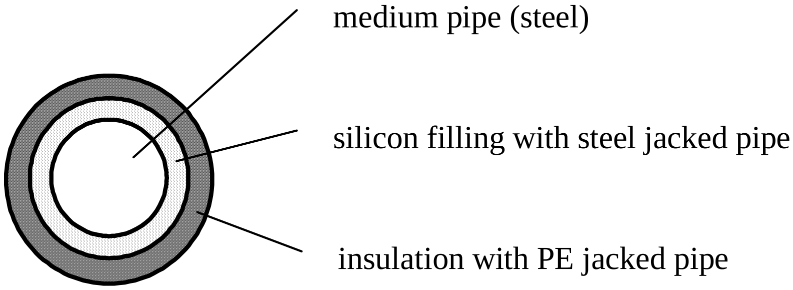

Figure A1. New proposed piping system.

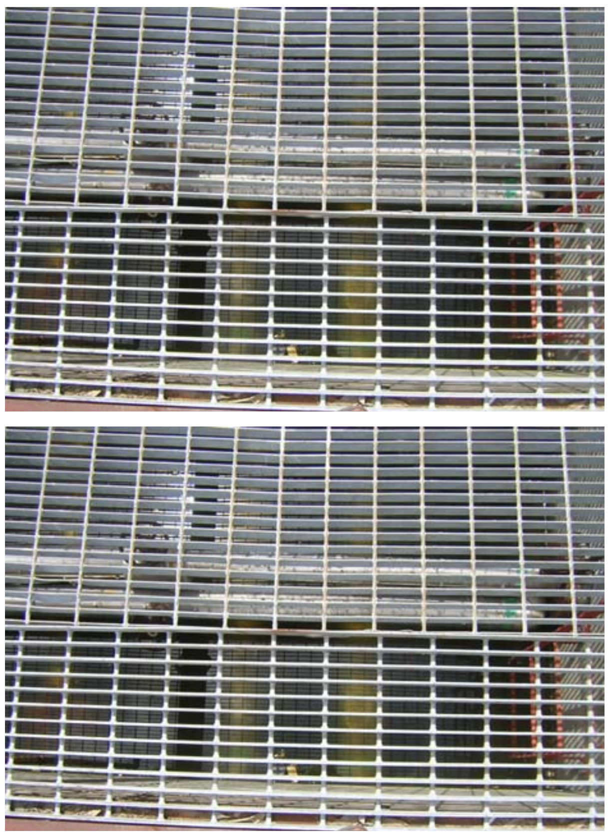

Figure A2. View inside a pit-hole with pipes beneath water level inside.

In the buildings, the energy taken from the DH system is converted by heat exchangers. Therefore the high temperature is reduced from 380 °F to at least 180 °F for space heating. The DHW preparation is a storage system, using the 380 °F for heating up. The design parameters of a building converter station are:

- TSHW = 380 °F
- TRHW = 230 °F
- ΔT = 150 °F

Figure A3 shows the converter station in the buildings. This schematic drawing indicates that the connection of the space heating system of the buildings (secondary side) with the DH system (primary side) is only thermal but not hydraulic. Both systems are decoupled hydraulically. It is assumed that so called pipe-bundle heat exchangers are installed. However, Figure A3 shows that the DHW heating is connected to the primary system with its high temperatures. Figure A4 outlines the DHW heating system and hooks-up to the connection shown in Figure A3.

The maximum heating load amounts to 81.570 MMBtu/hr (= 23.906 MW). The base load for DHW preparation equals 13 percent of the peak load. Thus the base load amounts to 11.000 MMBtu/hr (= 3.223 MW).

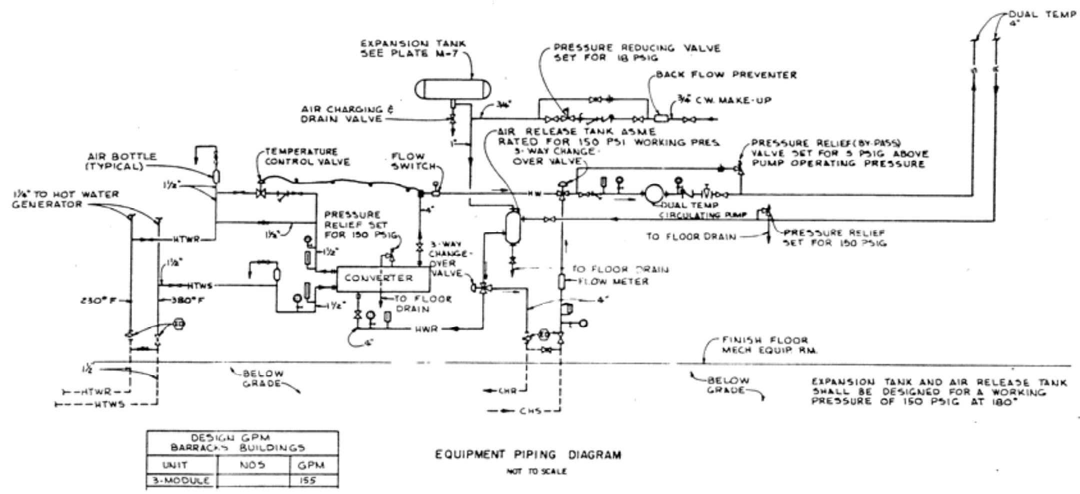

Figure A3. Equipment piping diagram.

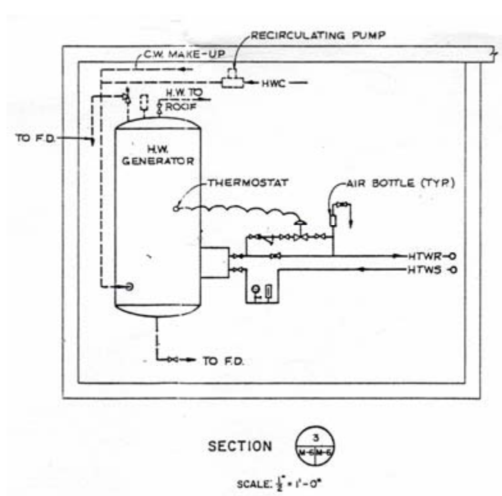

Figure A4. DHW generator.

In the hospital, the high temperature hot water is used to generate steam for the sterilization. And at the site of the hospital a natural gas boiler with a capacity of 6.250 lb/hr (= 2.835 kg/hr) is installed. This boiler is designed to supply the entire demand of the hospital. Nevertheless it is connected to the DH systems. Here the standard parameters are:

- TSHW = 355 °F
- TRHW = 275 °F
- pSHW = 180 psig
- pRHW = 150 psig.

At Hunter Army Airfield (HAAF), only one CEP with two HTHW boilers and one low temperature hot water boiler (LTHW) was listed. The low temperature boiler is utilized for the current heat generation, since the capacities of the high temperature boilers suffice. With these boilers, two DH Systems are supplied: one high temperature, and one low temperature hot water system. Table A1 lists the parameters.

Compared to the Fort Stewart system, the water is treated and leakages are of no issue at HAAF. The cost for the treatment amounts to $5.00 per day to treat 4,000 gal per day.

Solution

Due to the high heat losses in the existing DH system – which amount to approximately 50 percent – a reduction of the supply water temperature is the best conceptual solution to reduce those devastating heat losses. The majority of heat losses emerge during summer time when the DH system serves the DHW heating needs. Hence a second objective is the adaptation of the DH system's temperature to the outdoor temperature conditions.

Table A1. Parameters for high and low temperature district heating systems for HAAF.

	High Temperature DH System	Low Temperature DH System
TSHW	175 to 300 °F	140 to 160 °F
TRHW	~170 °F / 285 to 290 °F	130 to 150 °F
ΔT	10 to 15 °F during winter	20 to 30 °F during winter
	3 to 5 °F during summer	15 to 10 °F during summer
Utilization	Space heating + DHW	DHW for 8 blocks
		Well defined peak load hours:
		6.30 to 8.30 a.m.
		4.00 to 6.00 p.m.
		for showering

A so-called sliding operation requires the implementation of an advanced control system. Applying the sliding operation offers both opportunities, meeting the demand for space heating and DHW heating during the heating period in winter and meeting the lucidly lower demand through summer, when DHW heating is the only demand. Figure A5 shows the proposed estimated temperature operation curve

Figure A6 shows a schematic drawing of the control system adapted to the outdoor temperature Note that, since three pumps are installed, three separate circulation systems are assumed. This control system is situated at the CEP and touches neither the CEP itself nor the steam circulation. The adjustment of TSHW is realized by admixture of return water into the supply water. It is important to emphasize that the secondary side of the system is not touched.

Besides the control system at the CEP, the heat exchanger situated in the buildings has to be matched to the lower temperatures. Lower TSHW but constant demands lead to higher mass flows in the pipes and/or longer terms for heating up the DHW storage respectively heating the building heating circulation.

If those longer terms are unacceptable, i.e., in the bathing rooms for the soldiers, these components have to be replaced by proper ones. In this case, the following solution promises best economic efficiency. Since the converter for space heating and DHW are connected in a different way to the primary side of the DH system, the following approach for the matching employs the same principle: the DHW heating installation uses the primary DH circulation and the space heating demand is connected with help of a heat exchanger. For this purpose, a so-called “DH compact station” is the best suited candidate (Figure A7). Both elements can be ordered in different scales. (Note: from Figure A7, the width amounts to approximately 8 ft at a capacity of 2 MW.)

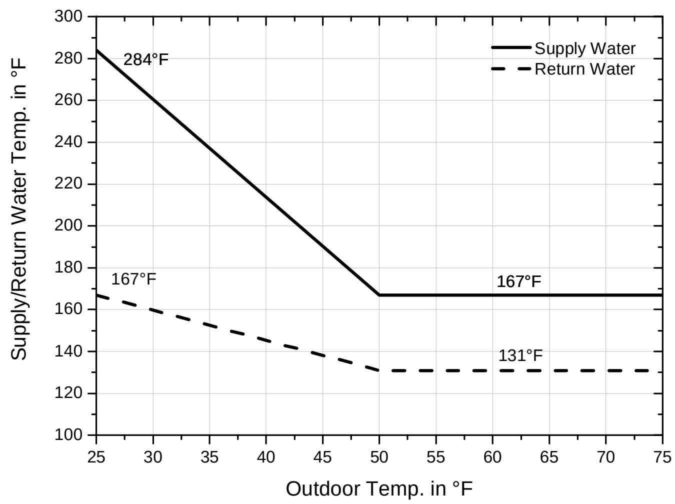

Figure A5. Proposed preliminary sliding temperature operation curve of the DH system.

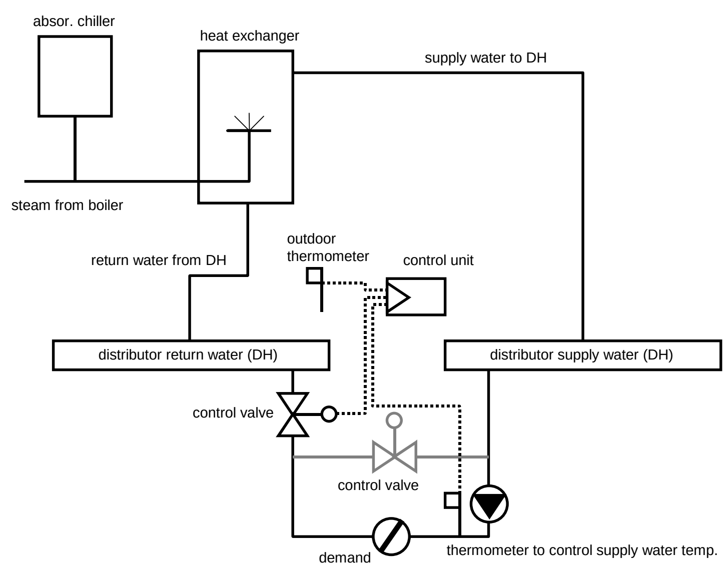

Figure A6. Schematic control diagram.

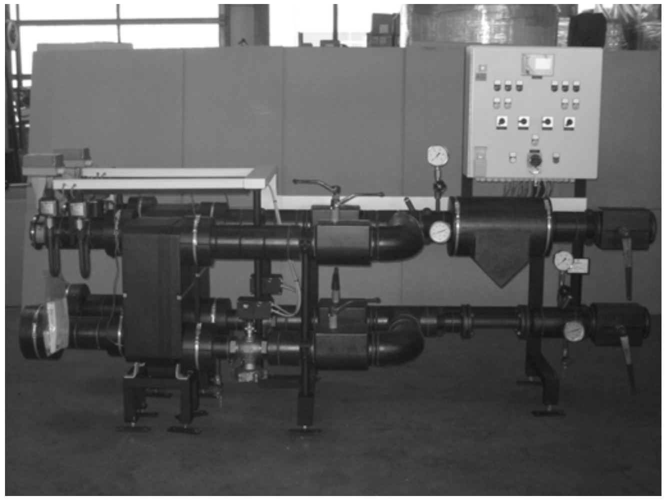

Figure A7. DH compact station.

The two processes – steam generation for sterilization in the hospital and for dishwashing in the DFAC – require high temperature heat during the whole year. Both processes can be supplied by the following alternative generation options:

- use of the backup natural gas boiler on the hospital side to heat up the DH supply water to the required temperature of 300 °F and installation of an additional backup boiler to ensure the supply reliability, or
- installation of electric dish-washers at DFACs.

Savings

Starting with the lower TSHW, the most important benefit is the reduction of the heat losses. The majority of those heat loss savings will take place during the summer, when the DHW heating is the only demand in the DH system. Regarding to the sliding temperature operation curve, the annual average TSHW will amount to about 205 °F. However, due to the fact that TSHW is constant through the whole year, today's annual average amounts to 380 °F. Assuming the ambient temperature of the pipes with 70 °F the temperature difference is like the quotient:

$$\frac{(205-70)°F}{(380-70)°F} = \frac{135°F}{310°F} \approx 0.4345$$

Presuming a linear relation of the heat losses to the temperature difference between the pipes and its environment, the heat losses in the supply pipes can be reduced by 43 percent.

On the other hand, today, the return water temperature TRHW averages to 230 °F. Since TRHW will be transferred to a sliding operation temperature as well, the annual mean is assumed with 150 °F, while the temperature in the environment should be 70 °F. Thus, the linear relation suggests that the reduction potential in the return water could reach 53 percent.

The heat loss in the piping system is about 50 percent of the total heat energy. The total heat energy in FY 2004 amounted to round about 300,000 MMBtu. Thus the heat losses equal 150,000 MMBtu, occurring in both, the supply and return pipes. A further assumption is that the today's heat losses are divided on the supply and return pipes by a ratio of 70 to 30 percent with the higher share at the supply side.

Considering all those assumptions, the potential energy savings in the supply pipes can be calculated as:

$$150{,}000 \text{ MMBtu} \times 0.7 \times 0.43 = 45{,}200 \text{ MMBtu}$$

In the return pipes the same approach results in:

$$150{,}000 \text{ MMBtu} \times 0.3 \times 0.53 = 23{,}900 \text{ MMBtu}$$

Thus, due to the proposed sliding operation temperature curve, the total potential of heat loss reduction amounts to 69,100 MMBtu. This is a total reduction of the heat losses of 54 percent compared to the current. Considering an efficiency of the plant as 60 percent, this heat loss equals 115,000 MMBtu of fuel for the CEP.

Finally those 69,100 MMBtu (thermal) of steam can be applied on a turbine to generate electricity with it. Assuming a theoretical Combined Heat and Power (CHP) plant with an electric efficiency of 25 percent, this steam equals an electric energy of 17,300 MMBtu (electric) per year.

Investment

All those measures described previously require a number of investments to upgrade and refit the DH system.

Starting with the control system to allow the seasonal sliding temperature operation, three separate circulations are considered. The determining factor for the design and investments calculation are the design parameters of the pumps in the DH system as listed in the Johnson Controls ESCO proposal.

Table A2. Investments for seasonal DH control system.

Number	Item	Cost per item	
		[EUR]	[$]
4	Control valve DN250, PN25	4,500	5,295
2	Control valve DN150, PN25	3,000	3,530
8	Lock fittings DN250, PN25	3,500	4,120
4	Lock fittings DN200, PN25	2,500	2,940
4	Dirt trap DN250, PN25	3,500	4,120
2	Dirt trap DN 200, PN25	2,000	2,355
200 ft	Steel pipe incl. insulation DN250	72 per fd.	85 per fd.
	Accessories (thermometer, pressure gauge, ...)	1,500	1,765
100 ft	Steel pipe incl. insulation DN200	60 per fd.	70 per fd.
	Accessories (thermometer, pressure gauge, ...)	1,200	1,410
2	DH controller with external sensor	2,500	2,940
1	DH controller with external sensor	2,500	2,940
Sum		*112,110*	*127,205*

Table A2 lists the investments for the seasonal control system will amount to round about $130,000 (without mounting, which increases the costs in Germany by 100 percent).

On the other hand, a worst case scenario assumes the replacement of all 102 heat exchangers in the buildings to adjust the entire system to the lower temperature levels.

In Figure A7, a so-called DH compact station with a capacity of 2 MW was shown. Such stations are available in different sizes. In an overview of 32 current heat exchangers in the buildings the average capacity of 30 of the heat exchangers amounts to 480 MBH while to larger ones have a capacity of 2,900 MBH and 3,600 MBH. Assuming this as a significant sample, those heat exchangers with design temperatures of 194/158 °F cost about $9,650 per 480 MBH unit. A unit of 3,600 MBH costs $42,900 (both without mounting which increases the costs in Germany by 30 percent).

In addition to heat exchangers for space heating, the DHW generators connected to the primary systems must be adjusted to the new temperatures. As mentioned previously, lower temperatures than the design temperatures of the DHW generators cause longer times for heating up the storage. This may be acceptable for 50 percent of the buildings, but it is unacceptable in buildings with shower rooms, in the dining room or in other similar areas.

The design size of a DHW generator shown in Figure A4 amounts to about 459 gal. Installing a domestic water transfer station with about 100 kW ($5,200) and – if needed – two hot water tanks with 200 gal each unit ($1,880) cost about $8,960 (without mounting, which increases the costs in Germany by 20 percent).

"Worst case" total costs for the adjustment of the system, assume that 94 heat exchangers with 480 MBH each and eight heat exchangers with 3,600 MBH must be replaced. This results in a total sum of about $1.25X106. Furthermore an assumed replacement of 50 DHW generators requires additional investments of $448,000.

The total costs for the replacement of those DHW generators, the heat exchangers for the buildings and the installation of the control systems amount to $1.83X106.

Note that this includes the material costs without mounting and without installing an additional backup boiler at the hospital and without installing electrical dishwashers at the DFAC.

Payback

Heat energy saved by lower DH system temperatures are calculated as:

69,100 MMBtu (thermal) per year (equivalent to 23% of the total heat usage in FY 2004) = $179,000 per year

Investments for the system's adjustment to lower temperatures:

$1.83×106, without mounting

Payback without interest in 10.2 years (without mounting and installing the CEP, but double consideration of the saved heat losses)

Notes:

- An efficient heat recovery from the flue gas to preheat the return water requires lower temperatures in the DH system.
- Reducing the temperatures in the DH system does not necessarily entail the replacement of all heat exchangers, but entail the replacement of several heat exchangers.
- Reducing the temperatures in the DH system does not necessarily entail the replacement of 50 DHW generators.

Reducing the temperature and installing a CEP plant at the same time offers the chance to expand the steam with the turbine to lower pressure. Thereby more from the enthalpy from the steam can be used to generate electricity – in particular during summer. But this maybe requires the replacement of the old cascade heat exchangers in the plant by adjusted ones. However, the steam circulation of the entire plant can be optimized if a maximum electricity generation is desired, but this strongly depends on the design of the turbine. Since this design was not known at the time of this study, calculations for the resulting benefits are not included here.

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14. ABSTRACT

An Energy and Process Optimization Assessment (EPOA) was conducted at Fort Stewart, GA (FSG) to identify energy, process, and environmental opportunities that could significantly improve the installation's mission readiness and competitive position. The study was targeted at creating a holistic approach to energy optimization in both non-industrial and industrial facilities and included measures related to industrial processes, building envelope, and energy and mechanical systems. A team of re-searchers and expert consultants performed a Level I EPOA for 2 weeks beginning18 July 2005. The scope of the EPOA included: the central energy plants at both Fort Stewart and Hunter Army Airfield, several industrial and non-industrial buildings, and an analysis of their building envelopes, ventilation, compressed air systems, lighting, and individual steam boilers. The study identified 42 energy conservation measures (ECMs); 22 of these were quantified economically. Implementing the 22 ECMs will re-duce FSG energy and operating costs by approximately $1.89M, will yield an average simple payback of 5.3 years (64 months), and will improve the work environment.

15. SUBJECT TERMS
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